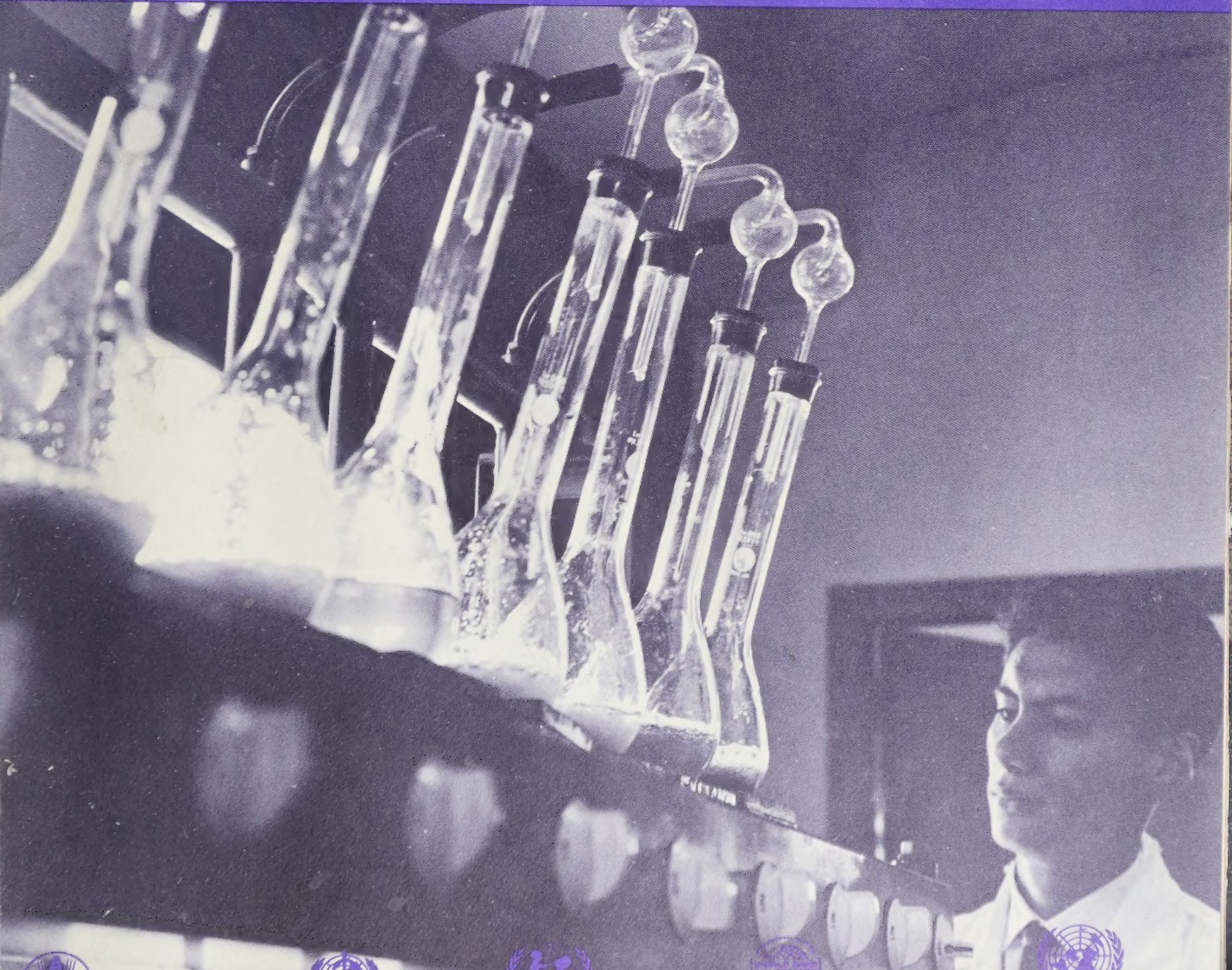
VOLUME V, NUMBER 2, JUNE 1975

TECHNOLOGY EXPERIMENT STATION
C.F.T.R.I.
5.1.76
MANGALORE

PAG BULLETIN

Protein-Calorie Advisory Group of the United Nations System



Food and Agriculture Organization of the United Nations

World Health Organization

United Nations Children's Fund

International Bank for Reconstruction and Development

United Nations

PAG Bulletin **Volume V, Number 2, June 1975**

COVER:

The laboratory apparatus on the cover may seem arcane and mysterious to the unitiated, yet it is a familiar sight in laboratories the world over--wherever amounts of protein or other organic nitrogen-containing substance must be determined chemically. Since most of this issue of the Bulletin is devoted to a PAG Guideline dealing with protein methods for cereal breeders, a cover photo showing one of the methods was chosen.

Readers with even a passing familiarity with chemistry will recognize the apparatus to be that of the Kjeldahl method: samples are boiled for many hours in sulfuric acid with other added reagents; alkali is then added so that the nitrogen in the sample finally is converted into ammonia, the amount of which can be determined by any of numerous methods. The amount of protein in the original sample is then calculated on the basis of the ammonia measurements by use of an empirical number representing the proportion of the protein that is nitrogen.

What about the originator of the Kjeldahl method, whose name appears--in lower case--in four different entries in our dictionary: kjeldahl, kjeldahlization, kjeldahlize and kjeldahl flask (several of which appear in the photograph). His full name was Johan Gustav Christoffer Thorsager Kjeldahl (1849-1900), a Danish chemist who first published the method in 1883. He is less well remembered for his work on the chemistry of sugars, to which he devoted most of his career, and for his distinction as first head of the Carlsberg Chemical Laboratory in Copenhagen.

(continued on back cover)

IN THIS ISSUE....

PAG Bulletin, Vol. V, No. 2, June 1975. *PAG Bulletin* is published quarterly in English, French and Spanish editions by the Protein-Calorie Advisory Group of the United Nations System, Room 606, 866 United Nations Plaza, New York, N.Y. 10017, U.S.A. Controlled circulation postage paid at New York, N.Y., U.S.A.

PAG BULLETIN

VOLUME V, NUMBER 2
JUNE 1975

PAG STATEMENT (NO. 28): ISSUES FOR THE WORLD FOOD CONFERENCE, THE PAG VIEW*

FISH TECHNOLOGY EXPERIMENT STATION
C.F.T.R.I.
5-1-76
MANGALORE.

The food problem and its complexity

Despite a growing awareness by the United Nations system and by national governments of the pivotal role of nutrition in national development, the steps so far taken to increase food production and food availability in developing countries are hardly adequate to meet the minimum nutritional needs of a majority of the population.

In the food supply sector alone, mounting difficulties exist. Unforeseen climatic disruptions such as failure of monsoon rains as well as the lack of reliable data on food crops and their consumption cause difficulty in projecting trends in food production and availability. The major pressure on the world food supply will be population increase, and this will continue to be the case for many years even if family planning programs were to begin yielding results from now on. Water, improved seeds and more fertilizer are the three essentials for increasing overall world food production. The supply of nitrogen fertilizers, which has been a limiting factor all along, is now acute. This will continue as long as petroleum is scarce or costly and as long as investment for fertilizer production facilities remains limited. Use of fertilizer stimulates the production of more grain in the developing countries than in developed countries, where its use already yields diminishing returns. Power and fertilizer are important not only for the productivity of high-yielding crops where they are under irrigation, but also for increased agricultural production in semi-arid regions. The advantages of fertilizer combined with the fact that it costs less to transport than the food shipments that would be needed in the absence of fertilizer-induced higher food yields should stimulate provision of fertilizer instead of grain in international aid programs.

Recent cycles of below-normal rainfall and the depletion of ocean fisheries are current serious problems. Pre- and post-harvest losses to rodents, birds, insects and fungi continue to be excessive.

Since it is vital that increased employment at adequate wage levels should accompany food production in the developing countries, agricultural operations should use simple labor-intensive and diversified agricultural technology. Such technology can produce nutritional

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*Statement prepared at 22nd PAG Meeting, June 1974, Rome and subsequently presented to the World Food Conference, Rome, November 1974.

benefits as a result of the increased purchasing power they generate. An examination of the food emergency on a global basis should not omit consideration of special or complex factors unique to specific countries. Any analysis of the serious global grain situation should not overlook the constraints on the production of legumes; an increase in their productivity awaits significant research breakthroughs.

Increased prices of all common foods have seriously affected the nutritional status, health and well-being of a majority of people in developing countries, particularly infants, children and pregnant and nursing women. This human aspect of the problem is largely due to social inequities related to inadequate food distribution and constraints on consumption. In rich and poor countries alike this inequity is exemplified by the increased demand for animal products by the affluent, which causes shortages and increases the prices of all those products (principally grain) that are the staple foods of the poor. To improve nutrition, increased food production alone is insufficient; there should be distributive justice as well. Humane social strategy should parallel economic strategy in order to distribute fairly the benefits of increased production.

As for the public health aspects of nutrition, programs responding to the needs of vulnerable population groups have remained token in character. Because safe drinking water and environmental hygiene are still luxuries in most of the developing world, diarrheal disease and intestinal parasites cause an additional burden for hundreds of millions of people. Problems such as pesticide-resistant malaria mosquitoes and schistosomiasis in newly-irrigated areas are increasing.

The present world food situation is not a crisis that appeared only very recently; it is a situation that has been building up due to several long-term causes that had not been clearly perceived or acted on. We now have an emergency superimposed on a chronic crisis, which is reflected in the present very low world grain supplies.

The PAG views with concern the increasing impact of these developments on a pre-existing crisis situation and notes their serious implications for the nutrition and well-being of low-income populations in both developed and developing countries.

The need for long- and short-term programs

On the basis of experience and observation in a number of developing countries, useful strategies and programs can be undertaken for improving food production and nutritional status; these would include long- and short-term programs of action based on evaluation of alternative strategies under a given set of socio-cultural and agro-ecological conditions. It is important to match every technological package with an appropriate combination of services and of public policies. Such packages can be developed only from detailed local studies, including careful assessment and comparison of the effectiveness and cost of ongoing nutrition programs. Establishment of a nutrition policy, selection of strategy and implementation of programs require a minimum data base. The assembly of such a data base would involve the use of selected health, nutrition, agricultural and socio-economic indicators and simple techniques for diagnosis of malnutrition and its causes.

Data base for planning and strategy development

There are limitations in the use of macro or aggregate economic and demographic indicators for economic, agricultural and social planning for the alleviation of malnutrition in populations. These limitations make difficult the identification of the nature and distribution of nutrition problems. Nevertheless, adequate data on the nutritional status of a population is vital for the elaboration of policies aimed at improving its nutritional situation. Food balance sheets give sufficient information neither on the distribution of food within the country nor within the various socioeconomic

groups of the population nor among members of a single family. They are therefore of limited use in nutrition policy and program planning. Better sources of data are food consumption surveys, but only a limited number of them have been made in developing countries; those surveys that do exist are not always adapted to the purposes of nutrition planning. Despite their limited applicability, micro or disaggregate data are helpful for specifically determining the nature and distribution of malnutrition in a population. The following micro data would provide useful information:

1. Food consumption obtained from surveys of families in different socioeconomic and occupational groups within a country and expressed per caput are valuable for drawing inferences on the existence of nutrition problems.

2. Data on the food consumption of individuals make it possible to determine the probable nature and frequency of nutritional deficiencies within groups.

3. Direct examination of individuals for anthropometric measurements, clinical signs and biochemical changes remains the only way to confirm the prevalence and severity of specific types of malnutrition in a population.

4. Even in the absence of comprehensive clinical and laboratory evaluations obtained from appropriate samples, most countries have sufficient data from hospital records and surveys of various types that can help confirm the public health, social and economic significance of major nutrition problems and can justify proceeding with remedial policies and programs. Such data are useful even when clinical and laboratory evaluations using appropriate sampling techniques are not available.

Periodic surveys of the type described above are required for evaluating programs and assessing trends. Since neither alone is sufficient, the PAG recommends that both macro and micro data be used in combination for food and nutrition policy planning by governments and United Nations agencies.

Integrated packages of nutritional improvement

In the short term, current programs for mitigating malnutrition among priority groups should be further strengthened through activities such as surveillance, institutional management of cases, supplementary feeding, prompt treatment of diarrheal diseases, control of infections, nutrition education and demonstration, etc. Such short-term intervention programs should not, however, preclude action on long-term integrated programs designed to provide the health, educational and developmental infrastructure needed for sustained improvement of nutritional standards. Indeed the short-term programs may provide opportunities for data collection and analysis valuable for designing long-term programs. The addition of a nutritional dimension to national development planning could help to ensure that allocations of resources for development, individually or in combination, do not have adverse impacts on nutrition. In particular when resources are scarce, complementary actions that enhance one another are needed.

The completion of the unfinished public health revolution in most poor countries is an urgent matter. The major components of this revolution are eradication of communicable diseases through provision of safe water supplies, immunization and other measures; delivery of food supplements such as essential vitamins and minerals in appropriate forms; periodic treatment for intestinal parasitic infestations; provision of food subsidies and clothing for vulnerable groups; and extension of primary school programs. Unless these programs are fulfilled in a scheduled or time-bound manner, positive nutrition programs are liable to remain token measures and will show no perceptible benefits. Accordingly, national, bilateral and multinational efforts should take two major approaches:

1. The development and delivery of integrated packages of nutritional improvements with synergistic interactions between nutritional and non-nutritional pathways of rural development; and

2. The design of the programs so that the input from outside the country eliminates itself and the local effort becomes self-perpetuating.

Program development would call for detailed consultation with the people of the area and should take into account the cultural as well as the socioeconomic and agricultural conditions of the locality. An example of this approach is the support of small-scale agriculture to increase productivity by means of strategies such as better access to credit, assured availability of water for irrigation, expanded extension programs backed up by intensive agricultural research, easy access to public services, and new forms of rural institutions and organizations that promote the above efforts. Other relevant programs are the supply of safe drinking water through distribution or provision of easy access to water sources; support for development of village production of foods for family needs along with facilities for their storage and preservation; and provision of basic health care facilities appropriate to the needs of the area.

Now urgently needed for intensive testing is a new kind of community development project that would require the involvement of appropriate agencies in an altogether different style. The projects should be implemented by village organizations with the association and support of appropriate government departments and with the assistance, wherever requested, of the appropriate international organizations of the United Nations. An important objective is to generate self-sustaining local effort through village leadership with the involvement of other village members to develop and use simple practical measures for nutritional improvement. Such pilot projects are urgently needed everywhere, particularly in the semi-arid areas. The research underpinning for such projects should be available from national and international research institutes, not only in health, nutrition and agriculture but also in socioeconomic areas. Participation of the academic community, including students, in such projects might be of great value. The proposed United Nations University also could ultimately become involved in such nutrition-related community and economic development projects.

Recommendations to the World Food Conference

The PAG notes with satisfaction that the United Nations World Food Conference will give serious consideration to the following topics among others:

1. The limitation of food availability in consequence of the limited availability of fertilizers. It is imperative that the necessary financial, material and human resources be found to increase the rate of construction of fertilizer plants, paying particular attention to the recovery and use of flare gas as a raw material. Many less-developed countries will need help to manufacture and/or buy fertilizers. The PAG considers it important a) to evaluate the relative economic and nutritional advantages to recipients by providing fertilizer aid rather than food aid and the effect of such a change on the attitudes of potential donors and b) to determine the useful impact that food aid programs have had on a number of recipient countries in the past.

2. Implications to food production of the rising cost of power and the shortage of energy to operate agricultural machinery and irrigation systems. Inadequate irrigation systems are a serious constraint to agriculture in many countries of the tropics, especially affecting the production of the high-yielding cereal varieties. The availability of power and water supplies for food production must be assigned highest priority.

3. Maintenance of emergency food reserves. Careful consideration should be given to the size, location, distribution, storage, allocation and overall management of such reserves. Particular attention must be given to the potential impact of large grain reserves upon the production and prices of grains in both developing and developed countries. Careful attention should also be directed to the many technical problems related to the storage, handling and distribution of large reserve grain stocks, particularly in tropical countries.

In addition to the above issues, the PAG commends to the United Nations World Food Conference the following as matters for serious consideration:

1. Opportunities for gainful employment and income generation. The course of growth of agricultural production and national economies in general should be charted in the less-developed countries (LDCs) so as to benefit the poor by increasing opportunities for gainful employment. Efforts should be made to develop food and agricultural processing industries close to sites of agricultural production in order to diversify employment among agricultural workers. Efficient labor-intensive techniques should be applied to all aspects of harvest and post-harvest technology (grain storage, transport, processing, etc.) in the developing countries. In order to assist them to increase their export trade, the technologically advanced countries have to adopt appropriate policies of agricultural and technical adjustment.

2. Relative merits of food crops versus cash crops production. It has to be appreciated that agriculture should be sufficiently diversified in most developing countries and that cash crop production is essential if only to sustain a desirable rate of growth of gainful employment thus helping to stimulate demand for and supply of locally-produced food crops. The relative emphasis that agricultural planning should stress between food crops and cash crops is a question that must remain the responsibility of national governments. However, much can be learned from the elaborate production, protection, marketing and transportation systems already developed for cash crops in many LDCs. These systems should be applied or adapted to production and post-harvest systems for food crops as far as is relevant and possible.

3. Support for agricultural research, extension services and training. There is an urgent need for higher levels of support for agricultural development research, extension services and training in developing countries. Support for the established international agricultural research centers needs to be continued and, where necessary, expanded. In addition, national and local agricultural research and training institutions need considerable strengthening in almost all LDCs. These research, extension and training services should concentrate upon increasing production and should include more efficient use of fertilizers, organic recycling and biological nitrogen fixation, integrated pest control, greater resistance to drought stress and improved high-yielding capabilities with better nutritional quality in food crop varieties. Particular emphasis should be given to improving the total post-harvest system including plant protection, crop storage, processing, distribution, marketing and pricing mechanisms, etc. These improvements could be provided in project "packages", which are financeable and amenable to efficient integrated management. Every effort should be made to emphasize the importance of agriculture and to enhance the dignity and worth of agricultural workers in the less-developed countries.

4. Expansion and improvement of programs in nutrition education. Nutritional improvement for the large majority of people will require substantial changes in food habits and eating practices, particularly as they affect the nutrition of infants and other vulnerable groups. Because such customs are among the most deeply ingrained in any culture, success will require massive and sustained

programs in nutrition education and training--mainly of a nonformal nature. High priority should be given to the expansion and improvement of such programs.

5. Need for special foods for small children and other vulnerable groups in the population.

Special attention should be given to the availability of adequate amounts of protective foods as sources of energy and inexpensive protein for small children and of other essential nutrients for the entire population, particularly for those in the poorest groups.

6. Family health and family planning. Developing countries should keep in mind that without appropriate policies relating to child health and population, no food and agriculture policy will succeed in the long run to improve consumption levels and nutritional well-being.

7. Special problems of feeding in emergencies. Careful thought should be given to the physical form in which cereals are made available to meet emergency conditions, as well as to the channels through which they are to be effectively distributed in urban and rural areas.

8. Conservation of fish resources and their proper utilization. It is a matter of international urgency that conservation be enforced in fish harvesting. The depletion of aquatic resources by coastal pollution is a related problem. Greater attention should be paid to research and development of food production through aquaculture and mariculture. The direct utilization for human food of fish presently used for animal feeding (fish meal) and of species presently discarded should be encouraged. Greater attention needs to be given to simple inexpensive methods of fish preservation in order to permit wider and safer distribution of this valuable protein resource.

9. Overconsumption of food--risk to the consumer and effects on food availability.

The steady increase in consumption of animal products in developed countries to levels far beyond any nutritional need is a matter of concern from two viewpoints. On the one hand, food production based on feeding grain to animals limits the availability of cereal grains and grain legumes for the world population at large; on the other, a high intake of animal products (meat, eggs, dairy products) in many developed countries appears to lead to increased mortality from cardiovascular diseases. Each country must critically examine its animal food production system to ensure that it is based to the maximum possible extent on the utilization of resources that are not used as human food. For example, use of pasture grass for beef production should be favored above utilization of grain for fattening.

Supplementary Statement*

National and International Programs of Action

The PAG supports establishment of policies and programs for setting aside a 10 million ton grain reserve for use in international emergencies and for provision of concessional aid. It urges the launching of an intensive attack upon diseases and disabilities due to malnutrition. The PAG proposes the immediate expansion of programs designed to overcome major protein and energy deficiencies in children, and pregnant and lactating mothers. It further urges a time-targeted program be drawn up to eradicate the scourge of blindness arising from Vitamin A deficiency and of iron-deficiency anemia, goiter, hookworm, schistosomiasis, onocherchiasis and measles, all of which can be controlled through programs involving appropriate prophylactic and curative measures.

The PAG considers the nutritional welfare of young children to be a sensitive index of the nutritional status of the total population. It

*This portion of PAG Statement No. 28 is part of the World Food Conference documentation as United Nations document E/CONF.65/C.1/L.4.

emphasizes that simple physical measurements of children can be applied which permit establishment of useful and effective national nutritional surveillance systems. By such means, Governments would have constantly available a reliable indicator of national nutrition status.

The PAG appeals to both national and international agencies to develop nutritional improvement strategies which can be readily sustained and carried forward by Governments after external inputs are withdrawn. In this connection, the addition of a nutritional quality dimension into national agriculture and crop planning is required, so as to improve the quality of diets, particularly those of infants and young children. Such priorities should also take into account the urgent need to correct deficiencies of vitamins and minerals through appropriate local production and consumption of vegetables, fruits and other crops, and the need to encourage the home production and consumption of nutritious weaning foods. The role of local women and of the village school, its staff and the children themselves in popularizing such activities is crucial. Such projects would also help to generate additional employment and purchasing power among the poorest segments of the population.

Above all, the PAG stresses the urgency for Governments to recognize that the nutritional welfare of their people, based on a food supply of adequate quality and quantity, readily available to those groups having the lowest incomes, must be given the highest priority in their plans and projects for social and economic development, and that their national policies and the provision of resources on behalf of this priority must reflect its overwhelming importance.

NUTRITION STRATEGY AND PROGRAMME DEVELOPMENT
AN APPROACH

Leonard Joy*

This paper is intended to be complementary to that of Asok Mitra (1). It discusses the approach to nutrition problems from which should stem decisions about intervention measures and the data services necessary to appraise them.

Consider a severe case of infant protein-energy malnutrition that you have observed. In all probability it was associated with infection. Treated in a hospital the child made a miraculous recovery; returned to the family it suffered a relapse. Treatment of the immediate symptoms cured the immediate condition, but more fundamental measures were called for to treat the chronic condition. Moreover, they needed to be applied not to the child but to others: the mother perhaps, and more generally, the family and its employment, income, home environment and possibly, to the community at large to which the child belonged.

Typically, there is a seasonal pattern of malnutrition and sickness perhaps related to seasonality in birth patterns, harvests and earnings. Typically the family concerned is poor, maybe so poor that its income could not buy sufficient food to meet its calorie requirements even if income were wholly and efficiently spent on food (2). Typically, the wage earners are under-

*Member, PAG. Edited version of paper (PAG document 1.17.18) for the 22nd PAG Meeting, Rome, June 1974.

employed, but maybe at existing wage levels they could not meet calorie requirements for the family even were they fully employed (2). In the cases given in the just-noted study, the laborers' wages paid for the extra energy requirements of their work but left little over to boost the intakes of their dependants. In such situations the family's dependency ratio would critically determine the fate of the younger children and the strength of the wage earner would be critical to the survival of the family. Thus, infants may be given low priority in the family's food allocation out of necessity rather than through ignorance of needs, as Mitra states (1).

In different countries and in different groups or regions within a country, the details of the etiology and ecology of malnutrition will have their own characteristic constellation and flavor. But three features are likely to be universal: a) the inseparability of the symptoms due to malnutrition from other symptoms of deprivation; b) the inseparability of the fate of the individual from the fate of his immediate social group; c) the inseparability of the fate of deprived groups from the fate of the wider society in which they are found.

The identification of measures for solving the problem of malnutrition can therefore be pursued directly in relation to specific classes or groups of individuals and the symptoms of malnutrition that they present, and less directly, to the more or less proximate causes of their condition. We can seek both to cure and to prevent. As always, in the choice of balance of preventive and curative measures we need to take account of their impact on the evolution of the problem.

Distressingly, there is little quantitative analysis to predict the numbers of malnourished; predictions of food supply per caput do not serve this purpose. However, crude but reasonable assumptions lead us to suppose that in many countries the numbers of malnourished will grow, relatively and absolutely, to alarming proportions in the next decades. This proposition, which is in urgent need of further investigation, is likely to sway our advocacy towards giving greater emphasis to preventive measures.

The identification of measures to prevent malnutrition depends on an understanding of who the malnourished are and how they emerge as malnourished. First we need to define the malnourished. This must be done in terms relevant to identifying what can be done to ameliorate their condition or prevent its occurrence. Thus, while it is helpful to say that the symptoms of frank malnutrition are seen in children and especially those between the ages of 6 and 18 months, it is not sufficiently helpful. Indeed, it could be misleading if it encouraged us to try feeding extra food to these children where such a policy was likely to be inefficient or have only a transient effect. Further, we need to be able to subclassify malnourished children as the children of landless laborers, nomads or carpet-weavers, etc. We need to know who they are in socioeconomic and demographic terms, otherwise we shall not understand what sorts of measures are relevant to their condition nor how they need to be designed to meet their special needs. It may be more relevant to look to the condition of the landless--or the nomads or carpet-weavers--rather than to the condition of "children 6 to 18 months". At least it is likely to be necessary to distinguish the socioeconomic status of these different children. In addition it will be indispensable to have a detailed understanding of the ecology, and the family and community environment in which they live if relevant and effective measures are to be designed to meet their condition.

As we become better able to predict the future extent of malnutrition and who are likely to be affected, so shall we be better able to understand the kind and the magnitude of measures necessary to change the conditions which give rise to the problem. Since choices are to be made between preventive and curative measures, it is important to understand the nature and implications of the various alternatives.

Broadly speaking we can characterize the problem of malnutrition as a problem of deficiency of effective demand. That is, of people who either cannot or choose not to consume the foods they need. Seen in this light, nutrition policy must aim to increase the effective demand for appropriate foods by or on behalf of those whose intakes are deficient. This may involve education programs, but the central feature of nutrition policy will be measures to increase real incomes among the poor. This might be attempted in a variety of ways:
1. Reducing the prices of staple foods (e.g. general consumers' subsidy; a subsidy to specific consumers; reducing food production or supply costs; reducing fluctuations in supplies);
2. Increasing incomes (e.g. employment creation; raising productivity; assisting people to acquire assets; income subsidies);
3. Avoiding policies that cause or aggravate rises in food prices or that reduce incomes below levels at which malnutrition is manifested.

The avoidance of aggravating policies must be stressed as the most important of measures to attack malnutrition. Policies are especially aggravating when they speed the displacement of families from the land or from employment or when they fail to absorb as many on the land or in non-agricultural employment as they might. Population growth, technological change and the growth of commercial farming tend to result in growing numbers without claim to land. In many countries growing numbers of landless cannot possibly be absorbed by urban-industrial development. In these countries the pattern of farming and farming technology becomes critical in determining not only the extent to which there are increased food supplies for growing populations and the extent to which the potential benefits of farming improvements are realized, but, especially, they also determine the extent to which the benefits are shared. Development strategies can readily fail to ensure the sharing of benefits. In the short term, for example, measures such as land registration, which might be desirable for their long-run effects, could cause severe displacement and call for the careful phasing of complementary measures to absorb the displaced. An approach to nutrition planning at the area level would need to identify such determinants of malnutrition as well as identifying who the malnourished were.

Apart from the avoidance of harmful measures, specific positive measures might be identified under the general headings listed above. But these headings do no more than list classes of measures which would need to be conceived in concrete terms. It should not be assumed that because a particular class of measure might have a role in the attack on malnutrition, that this possibility is sufficient evidence that the net effect would necessarily be to reduce the number of malnourished. Thus the reduction of food supply costs might be achieved in a way that could have both positive (output increasing) and adverse effects (lower wage earnings for critical groups) which were on balance undesirable.

For nutrition policies the emphasis must be on generating effective demand among those who would otherwise be malnourished. Success in this will need to be matched by increases in food supplies, but the increases are by themselves likely to contribute to the solution or prevention of malnutrition only to the extent that they are accompanied by an expansion of effective demand by those most in need. Where effective demand is already increasing, it may be essential to identify the extent to which the increase is due to those already adequately nourished and to then devise ways to curb this demand or perhaps use it to subsidize those less adequately nourished. The increase in effective demand by the relatively wealthy leads to increases in meat supplies to satisfy their demands at the cost of reduced supplies and higher prices of grain for bread to meet the needs of the poor. The encouragement that we sometimes see for livestock production programs could actually aggravate the problem of malnutrition.

To the problem of diversion of grain to livestock production must be added the grave danger of falling grain supplies as a result of the oil crisis. It will lead to cost increases for fertilizers and other modern inputs and to a loss of impetus, perhaps a reversal, of the Green Revolution. The situation will call for supply strategies which emphasize "improved" rather than "high yielding" varieties and which aim to bring to market small surpluses from semi-subsistence farmers. Nonetheless, we can expect rising food prices to aggravate the problem of malnutrition especially among the underemployed landless poor.

While increased prices and decreased food supplies are important concerns, it must be remembered that malnutrition exists even when supplies are more than adequate--not simply on a global or national level, but even on the village level. Thus, one must consider not only national measures for generating or transferring incomes to the poor but also the possibility of village level action, including taxation. At the village level, too, there is scope for integrated programs featuring health care services as well as sanitation and water supplies--all of which would be complementary to nutrition programs.

Dr. Mitra's paper rightly notes that our knowledge of the relative roles of sanitation, disease control and nutrition is as yet inadequate for the definitive design of such programs (1). Yet ignorance about the relative significance of these aspects must be resolved ultimately by experience and by studying the results of carefully designed trials of alternative strategies. Nevertheless, the major problems in community approaches to health and nutrition are social, administrative and technical. Solutions to these problems also must be tackled pragmatically. While there is a useful body of experience to draw upon for designing, for example, rural health care systems, each country will need to find its own solutions to problems of community penetration, acceptance and support; to problems of training assistants and integrating different professional grades and functions into a coherent, motivated service; and to problems of routinizing diagnosis, treatment and referral both for individuals and for all communities with regard to their needs for drinking water, sanitation and prophylaxis. Within such a service might fall the responsibilities for mother and child care, nutrition education and family planning as well.

But such a service would immediately face such problems as how to care for the landless, unemployed squatter family unable to meet its own basic needs for food, housing, warmth, clothing and sanitation. More would be needed than could be offered at a health center. At some level more fundamental social action would be required. Jobs might need to be created, and in the short run at least, food handouts might be necessary. The action required could be taken by a central government or by a village community. It would necessarily involve some taxation of wealthier citizens, perhaps at the village level, and it would imply the acceptance, in some sense, of a community responsibility for a social problem.

It is here that the social and political aspects of nutrition policy are confronted with the issue of who pays and who benefits. The costs and benefits are to be accounted for not solely in material terms: power and status are heavily involved. Governments are likely to avoid measures that imply unpopular burdens for their political supporters. Thus, the governments most likely to undertake the required measures are those whose power depends on their doing so. Otherwise they will seek measures whose burdens are either slight or not too readily identifiable.

Failure to tackle the problem of malnutrition is not to be attributed solely to lack of political will. In part it is a failure to understand the nature of the problem and the extent to which it is growing. What we critically need to know is how the nutrition problem is evolving in each country. Who and how many will be the malnourished in 5, 10, 20 years? What

forces are at work to increase or diminish their numbers? How can these forces be controlled or modified? How and at what cost can the results of these forces be ameliorated? Until we have some idea of the nature and magnitude of the problem facing us and of the choices for meeting it we cannot confidently advocate any program, even those which we are confident will reach target groups in the ways intended; such "successful" programs may prove inconsequential and futile with respect to the central core of the problem and its magnitude.

The choice will be different for different countries as must be the objectives. Not all countries can aspire immediately to the highest nutritional objectives. Many countries should aspire to something more than minimal objectives. It might not even make sense for one country to apply the same objectives to all its localities or groups.

In each country the prime need is to begin defining the nutrition problem in a way that identifies policy objectives and priorities and the measures that will be relevant in tackling them. Generally, countries have only incomplete definitions of their nutrition problems. They may have estimates of the numbers of malnourished and of the nature of the nutrient deficiencies in relation to a standard, but they seldom have this information subclassified to show the relationship between nutrition status and socioeconomic status. Field workers often have a good general idea of this information and about what we have called the "etiology and ecology" of malnutrition in particular situations. However, too little of this knowledge is systematically available, nor is it made the basis of a systematic analysis of the relevance of alternative measures or for the design of chosen measures.

Countries do not as a rule have an argued statement of nutrition targets or priorities. Only too often international recommended intake standards are accepted as relevant immediate planning targets for all sections of the community. That these targets are accepted even though they may be inappropriate, and recognized to be so, leads not only to the avoidance of a serious questioning of proper targets and priorities but also leads to cynicism and a sense of helplessness in the face of insuperable problems. International views about priorities also obscure important policy choices. Perhaps it is right (i.e. socially desirable) in all countries to be concerned first with infants, mothers and children. But the people with nutrition problems do not always think so and this alone should give cause for disquiet. In any case, as we have noted, we need to distinguish between different children and we have to assert priorities and perhaps assign different levels of nutritional intake for different groups where they are competing for limited resources.

This paper has not listed many of the detailed measures that might be considered, not even under the general headings of classes of measures to be considered for increasing effective demand as proposed above. Nor has it discussed the need for specific classes of data (vital statistics, clinical, anthropometric, intake, income-expenditure etc.). It was not thought helpful to do so in a paper such as this. All countries are limited in their capacity for data collection and analysis. It is positively dangerous to write prescriptively in generalizations about data needs when countries have different problems, different resources, different planning and administrative structures and different choices. What is required instead is guidance on how nutrition policy decisions need to be approached and how to design data collection and analysis services for the purpose. The appropriate guidance will most critically depend on the existing level of sophistication in the planning structure and especially on whether or not there is area level planning. However, in all cases, it will stress the importance of the following:

1. Defining the target groups of nutrition policy in socioeconomic terms;
2. Detailed studies of the "profiles" of family and community situations in which malnutrition occurs such that the relevance

and design of particular measures can be effectively appraised before trials;
3. Assessing the relative roles of interventions to treat symptoms and interventions to tackle the immediate or more fundamental causes of malnutrition.

We are not yet able to generalize about the nature of the minimal measures needed to eradicate malnutrition. It seems likely that in some countries its eradication will not be possible through intervention measures which are addressed solely to ameliorating the symptoms of malnutrition. Moreover, it is not clear how fundamentally the necessary measures for attacking its causes will entail changing existing socioeconomic--and hence, political--structures. The more fundamental the social change necessary for the eradication of malnutrition, the more it will evoke resistance. Nevertheless, the present apparent failure of nutrition policies to secure strong political support in many countries may in large measure be accounted for by a failure to perceive the consequences of ignoring or underestimating the problem of malnutrition and to a failure to understand the true nature of policy choices for attacking it. On the whole, it is too much to expect that the process of routine planning will quickly illuminate these choices. There is a strong case, therefore, for the PAG to support the analysis of these larger issues on which the future of the world so critically depends.

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BRAZIL'S NATIONAL NUTRITION PROGRAM*

Carmen Hamann

The National Food and Nutrition Institute of Brazil is attached to the Ministry of Health, and is responsible for defining national food and nutrition policy as well as for preparing, coordinating and supervising the execution of Brazil's national nutrition program.

The Institute has recently established a four-year program, which encompasses the following:

*Presented but not discussed at the PAG ad hoc Working Group Meeting on Feeding the Preschool Child, Geneva, 10-12 February 1975. Miss Hamann is Director of Social extension--rural extension service, EMBRATER (Brazilian Enterprise for Technical Assistance and Rural Extension), Brasilia, Brazil.

Training

The main purpose is to strengthen the institutional basis of the organization and to prepare personnel for the Institute as well as for other agencies dealing with nutrition programs. In this regard special emphasis is given to:
-Multidisciplinary training on the national and regional level for medical, agricultural and social sciences graduates;
-In-service training or short courses to people already engaged in nutrition activities;
-The inclusion of a greater nutrition component in medical and agricultural undergraduate courses;
-Provision of funds for post-graduate courses or research studies of interest to nutrition.

Research and studies

Nutrition survey: the purpose of this project is to determine the nutritional status of the families with preschool children by studying consumption and intrafamily distribution of food as well as some clinical aspects related to the population. This survey will be complementary to the national food consumption survey, now in progress.

Studies are also to be made by the Ministry of Agriculture in close cooperation with the Institute, regarding the influence of agricultural policies on nutrition.

Food fortification

This program is aimed at the fortification of current foods like manioc and wheat flour, sugar, salt and other foods, with nutrients to help combat specific nutritional deficiencies. Specific emphasis will also be given to water fluoridation.

Food production and processing

Processed food: this project is aimed at the development and production of low-cost foods with high nutritional value. Coordinated action is being taken by the Institute and agencies responsible for research and production of this food.

Food production in low-income areas of rural Northeast Brazil: this project is designed to improve the nutritional status of small (working less than 50 ha of land) farmers and their families.

The following specific objectives have been defined:
-To increase the production of beans, rice and corn and a cash crop (cotton) in order to improve the income level of these families;
-To increase the consumption of beans, rice and maize;
-To provide stimulus to storage facilities at the family level;
-To develop health and nutrition activities related to basic sanitation, immunization, supplementary food distribution and medical assistance (when necessary), and health and nutrition education.

The project will be carried out by the Brazilian Enterprise of Rural Extension and Technical Assistance and has also the objective to test the effectiveness of the extension service as a delivery system related to nutrition programs.

Reaching preschool children through the school lunch program

The purpose of this project is to test the school lunch program as a delivery system for nutrition programs reaching preschool children. Food supplementation, education, and evaluation are included in the program.

Children age one to four years receive food supplementation at home with take-home foods. Children age four to six years will receive food plus education and social stimulation at the school. Mothers will receive training and nutrition education at the school. Routine home visits will be made to observe:
-If the food supplementation is being used in the manner planned;
-If it is necessary to re-orient the program;
-If reinforcement is needed in the education offered to the mothers at school; and
-To identify children requiring health assistance and to report on them.

Food supplementation and nutrition education

This project constitutes a nutrition intervention project through the normal health network, coordinated by the secretariat of health in each state, with the objective of providing food supplementation and nutrition education to infants, preschoolers, nursing mothers and pregnant women. Food for this program will be acquired through an agency linked to the Ministry of Agriculture and every effort will be made to use food produced within the country.

THE PHILIPPINE NUTRITION PROGRAM*

Florentino Solon

Because of the magnitude of the malnutrition problem in the Philippines and its broad and adverse effects on the nation's economy and education, the Philippine Nutrition Program (PNP) was launched by the government. It felt that the mobilization of human resources and maximization of efforts for economic progress lean heavily on a well-nourished and energetic population, all of which necessitate an effective and active national nutrition program.

Since good nutrition is considered a priority for overall socioeconomic development, the PNP takes an integrated approach to malnutrition by tapping the resources of the ministries of health, social welfare, education and culture, agriculture, local governments and community development, and other pertinent groups as well as foreign assistance.

The PNP aims to improve the nutritional status of the population, especially the vulnerable groups, such as infants, preschool children, pregnant and nursing women. Specifically, it is geared towards identifying, locating and curing the malnourished and preventing malnutrition among the vulnerable groups.

Besides directing its nutrition efforts towards the vulnerable groups, other policies provide for the following: health protection, treatment and rehabilitation of the malnourished; improving the economic resources of the family in cooperation with proper agencies; developing close coordination among family planning and nutrition technicians; promoting basic and applied research in nutrition and related sciences; designing an information and education program that will stimulate demand for indigenous foods and their maximum use; and coordinating all nutrition projects of both government and private groups.

The PNP's initial project is to conduct a nationwide "Operation Weigh-In" designed to pinpoint households with malnourished pre-school children, determine priority areas for program execution, and speed up the monitoring of malnutrition cases. As a priority project it has the support of government and private agencies. Trained weighing teams, aided by spot maps locating every household in the village, will conduct a hundred percent house-to-house weighing of all children under age six. The data serves as the basis of planning and implementing a nutrition program. Five intervention schemes or action programs will be implemented immediately:

a) Food assistance, which gives temporary emergency food relief to the malnourished. In this scheme, locally-processed nutritious food will be distributed once a week for six weeks to the malnourished.

b) Nutrition information and education aimed at informing and training the population, particularly the community workers and target groups, about simple nutrition and better nutritional guidelines. It also aims at integrating nutrition courses into school curricula. This is reinforced by the communication media.

c) Encouraging the production and processing of food supplements and the concomitant generation of additional income.

d) Health protection, which includes immediate medical treatment to malnourished children, especially those afflicted with diarrhea and other diseases.

e) Family planning, which is integrated with nutrition projects, envisions as a long-term

*Presented but not discussed at the PAG ad hoc Working Group on Feeding the Preschool Child, Geneva, 10-12 February 1975. Dr. Solon is Executive Director of the Nutrition Center of the Philippines.

goal, the trimming down of family size and reallocation of income and other resources to the malnourished.

For its strategy, the PNP is creating an effective organization to policy formulation, planning and implementation of action programs to meet its goals. It aims to mobilize available resources at various levels down to the grassroots and to maximize gains as speedily as possible. The National Nutrition Council (NNC) is the nerve center for planning and implementation and acts as the overall coordinator of all nutrition projects. The Nutrition Center of the Philippines (NCP) is the NNC's private counterpart to mobilize private groups for assistance. The NNC is headed by six cabinet ministers and three private representatives.

The government ministries involved have agreed formally to commit their services and personnel at all levels to the nutrition program. Nutrition committees have been formed at the provincial, local and city level. Provincial governors and mayors of towns and cities head their respective nutrition committees and coordinate all nutrition activities within their local jurisdictions.

Towns and cities have been singled out as the most vital and organic bodies for translating the national program to suit local needs and mounting a nutrition program of its own for its constituents. For instance, such a locality can set up a processing plant to produce nutritious foods to be distributed to the malnourished. Similar projects, including food banks, would be financed locally with foreign assistance when needed. Awareness of this task could convince the mayor to wield his taxation and legislative powers to support the local nutrition scheme.

Uniting behind the town nutrition committees are various village nutrition committees. Every village committee collaborates with a village nutrition network manned by community workers each responsible for twenty families. Each worker identifies, determines and monitors malnutrition cases and recommends intervention measures.

It is expected that at this level, every Filipino family will be reached and every malnourished child will be identified, located and treated accordingly.

PAG <u>AD HOC</u> WORKING GROUP ON FEEDING THE PRESCHOOL CHILD

The nutrition activities of local health services and emergency foods for infants and young children were among the topics discussed by a PAG <u>ad hoc</u> Working Group on Feeding the Preschool Child. Held in Geneva from 10 to 12 February 1975 at WHO headquarters, the meeting was chaired by PAG member Thomas Stapleton. Other items presented but not discussed at the meeting were reports on national nutrition programs in Brazil and the Philippines. (See pp. 12-15 of this issue.) Highlights of the discussions follow.

Nutrition activities of local health services

Improving the nutrition status of a population, including its children, depends on the availability of food, the socioeconomic conditions of the families, the degree of understanding of and response to nutrition and health education among family members, their awareness of the basic health and food needs, the environmental sanitary conditions and also, in large part, the extent and quality of the local health services. Since only important and minimal nutrition activities could be undertaken through local health services, the group felt it would be helpful if parallel but important programs

in the field of food production, simple preservation of foodstuffs, preparation of well-balanced meals, development of proper food habits and behavior, and so forth, were to be developed. These should be directed not only to mothers, but also to other adult family members, village leaders and school teachers, and should be incorporated into the basic training of various groups of national and local government workers. Such parallel activities are essential to help support health related nutrition activities.

Preventive measures, even more than curative ones, should receive emphasis even at the first and second stages of health service development. At the present time, however, because of the rapidly deteriorating food situation in many developing countries, the curative aspects have to be given great attention. The increasingly difficult food situation will probably result in a substantial increase in the number of children affected by different types and severity of nutritional deficiencies with an ensuing increased susceptibility to infections. Facilities for treatment as well as prevention should be part of the health center activity. The degree of severity of cases that could be handled must be determined; prevention also includes keeping moderate cases from becoming severe.

Countries ought to be able to choose the most appropriate activities for their particular situation, subject to availability of trained personnel and necessary facilities. Indeed, it would be advantageous to carry out pilot studies in selected centers in the countries to determine the extent and type of nutritional load that the health center and its personnel could cope with successfully. The philosophy should be that of gradual adaptation and adjustment to nutritional activities rather than that of imposition of a mandate.

The group felt that some activities of health centers are more important and urgent than others. These should be highlighted in the centers' personnel training and supervision. Suggested as priority activities were: cleanliness, pest elimination, breast-feeding, homemade weaning foods, immunization, programs.

In a program where graded activities are undertaken at different levels, it is essential to define the roles to be played by the different personnel and to spell out clearly the responsibilities for adequate supervision and continuous coordination. Primary health services are likely to function well only if the "next higher stage" exists for supervision. The health delivery system must be viewed in its entirety. Appropriate training facilities, both formal and in-service and an adequate communication system have to be provided.

Regarding the current problem of "creeping" deterioration of the nutritional situation, the group felt that studies should be undertaken to provide a monitoring system capable of forecasting the effects of changes in food availability and prices on the one hand and child nutrition on the other. The group considered the problem important enought to be a priority item.

Emergency foods for infants and young children

The group considered the role of foods from sources outside a country in the context of decreasing supplies originating from many industrialized countries. It also discussed the common problems experienced in the supply and utilization of such foods and ways to overcome some of the problems.

Processed foods particularly meant for children during emergencies play an important role, especially during the initial stages of a disaster, and where necessary, in continued use for several months thereafter. In disasters there may be some very young infants who cannot receive breast milk; they should be provided with formulas based on milk with added vitamins A and D. These formulas or their ingredients should be clearly labelled to state whether or not vitamins have been added. If milk is not available, it is essential

to provide special foods. For seriously malnourished young children, it is also imperative to offer special foods. It is desirable to provide a special mixture such as K MIX II along with the treatment necessary to initiate cure. For other children, a variety of nutritious combinations of foods can be provided, including processed weaning food mixtures commonly used in supplementary feeding programs.

Some common problems

The group noted that whereas bilateral or multilateral aid programs have been able to provide important commodities such as cereals over the years on a large scale without too many complications, considerable confusion has arisen with respect to certain foods for emergency use, particularly those meant for children. The group noted the following problems in particular:

a) Experience has shown that the continuing availability of donated foods such as milk powder and CSM is notoriously uncertain. When the supply of a product suddenly dries up, relief operations are dislocated. Often a bewildering number of products with various nutrient compositions and different methods of preparation are unloaded in irregular succession and often not in sufficient quantity.

b) Donor agencies have been largely uninterested in efforts to follow-up and study how the donated products have been put to use and their value for the nutrition and health of the intended consumers.

c) The shipment of large stocks of milk powder in various forms has encouraged the indiscriminate use of this valuable protein supplement so that all too often it has become the sole article of food for children in emergencies. The failure to provide adequate calories in skim milk powder can lead to undernutrition and other clinical problems, an example of the wasteful use of this precious protein concentrate.

Recommendations

The following recommendations were made by the group with respect to the above problems:

a) Donor governments, United Nations agencies such as the WFP and others, as well as voluntary agencies should be informed most clearly that for the time being and in all probability well into the future, there is and will remain the need for substantial commodity aid in the form of emergency food programs aimed particularly at young children.

b) In order to neutralize the adverse effects of fluctuating supplies of some widely used foods such as milk powder and CSM, governments and agencies should be encouraged to provide alternatives in the form of low-cost foods. This should be part of a preparedness program. The quantities of emergency foods needed are comparatively small in relation to those of foods (primarily cereals) that have been used in recent years in overall food aid programs.

c) There is no need to make available a large variety of products for any one emergency. Donors should be encouraged to develop food mixtures, appropriately processed, containing acceptable ingredients and conforming to the nutrient composition recommended for supplementary weaning foods.

It may well be that some countries, those who may not contribute importantly to the total world food basket, could undertake to provide most or all the needs for special emergency food programs intended for saving children. There is at least one country, Sweden, that has taken a step in this direction by preparing recipes for and guaranteeing the supply over a number of years of a sizeable amount of such emergency food. (See PAG Bulletin, Vol. IV, No. 4, pp. 26-30.)

d) In any case, research and development for such foods should take note of the suggestions

and recommendations given in PAG Guidelines Nos. 6, 7, and 8. With regard to nutrient composition, the group felt that PAG Guideline No. 8 required examination and review, particularly as concerns recommended protein content. Other problems that should be tackled in revision of the guideline are the need to enhance the calorie content of the foods and the usefulness of added sugar as a means of increasing their acceptability when viewed against the varying prices of sugar in the world market.

e) Misuse of emergency foods should be minimized. They are often intended as supplements to be given along with locally available staples. Thus with milk products, they should be used as a protein additive in other foods and not be given alone except to very young infants not receiving breast milk. Misuse has been observed in two directions: in the first instance, giving the supplement alone in the recommended quantity grossly undersupplies the child with energy; in the second, giving it alone in larger than recommended quantities wastes protein and other valuable nutrients.

It follows that food packages must be labelled clearly as to nutrient composition, ingredients used, whether it is a complete food or only supplement; if it is the latter, instructions should be given on its use as an additive and on its manner of preparation. Thus consumers should be given accurate and compelling instructions on the correct use of products, and to ensure this, trained personnel should be available to make certain that such instructions are followed. The latter need becomes all the more important if, as so often happens, one type of emergency food cannot be continuously supplied resulting in the use of various products of different composition.

Participants

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BOOK REVIEWS

By Bread Alone. Lester R. Brown with Erik P. Ekholm. 1974. Published for the Overseas Development Council. Praeger, New York and Washington. US $3.95 (paperback). 261 pp. & index.

This informative book deals with the current food crisis, analyzing the dimensions and complexities of the food supply problem from a global standpoint. It examines how the crisis came into being and then considers possible ways to deal with it. In their review of the impact of today's severely reduced availability of food and the explosive farm produce price situation on the nutrition of the vulnerable groups, the authors show how the prevailing circumstances have made conditions certain for the continuance and exacerbation of world malnutrition for the years and decades to follow.

In addition to population increases and the excessive demand for food by the affluent, other important causes stated for the present

and continuing crisis are the low rate of increase in agricultural production due to the drought cycle, constraints in inputs, inefficient use of natural resources, and increasing problems of pollution. To these are added the recent unstable world monetary situation.

Some of the steps suggested as solutions are a cooperative global approach to food production, marketing and distribution, rapid exploitation of unrealized food production potential in developing countries, and the preservation and proper development of environmental resources as well as the proper exploitation of the results of food production research. The authors also suggest the building of buffer stocks of food, and they recommend appropriate nutrition education in order to effect changes in food habits. As a whole, the book is a useful general resource for understanding the challenge posed by global food scarcity and the ways it can be met.

Proteins in Human Nutrition. J.W.G. Porter and B.A. Rolls (eds.). 1973. Academic Press, London and New York. US $26.50. 541 pp. & index.

If the number of citations given by others can be thought to have some bearing on the value of a work, then it may be of interest to note that seven of the fifty-two literature references appearing in PAG Guideline No. 16 in this issue of the PAG Bulletin refer to chapters in this book. This book is important because it is current, despite the fact that the proceedings on which it is based, a NATO advanced study institute on the chemistry, biology and physics of protein evaluation in Reading, England, took place in 1972.

As scientists, food technologists and agriculturalists have begun to be taken seriously with regard to the scientific and technical problems involved in improving the world's diet, this book sets out to consider protein resources, their applications and possible future developments. It also describes and critically assesses the usefulness of methods for protein quality evaluation in human nutrition.

Although many of the advances described in this book date back five or six years, it should serve those new to the areas it covers as a useful entrance to the literature starting in the early 1970s. The book falls naturally into four sections. First, various actual and natural protein resources are examined with current knowledge applied to the world food problem by such authors as J.C. Abbott, J.T. Worgan, B.R. Stallings and others. Then techniques for the assessment of the nutritive value of protein are considered in detail, many of which papers are cited in the PAG Guideline No. 16. Next, the role of the food scientist in the development and use of protein isolates is mentioned together with the techniques of quality control and the laboratory assessment of physical properties important for the formulation of new protein foods in papers by G.D. Rosen, D. Pearson, Ann-Marie Hermansson and P. Sherman among others. Finally, factors affecting protein utilization are discussed by authors including H. Zucker, I.E. Liener, P.A. Finot and H. Erbersdobler. The book concludes with a tantalizing peek into future, "The Way Ahead?" by N.W. Pirie.

Handbook on Nutritional Requirements. R. Passmore, B.M. Nicol and M. Narayana with G.H. Beaton and E.M. DeMaeyer. 1974. FAO/WHO, Rome/Geneva. (Published as FAO Nutritional Studies No. 28, available from FAO sales agents and also as WHO monograph Series No. 61, available from WHO sales agents.) £0.40, US $1.00 or Sw.fr. 12. 70 pp.

Among the many nutrition activities of FAO and WHO has been the gathering of statements--as accurate and generally acceptable as possible--on human nutritional requirements in order to provide a sound scientific basis for the programs and policies of their member governments. Over the past twenty years the two organizations convened eight expert group meetings, which have reported on energy requirements (calories) and many

of the essential nutrients: protein, vitamins A, B_{12}, C and D, thiamine, niacin, riboflavin, folates, calcium and iron. The results fill hundreds of pages of technical reports dealing with biochemistry, physiology, and clinical medicine, as well as with the epidemiology of deficiency diseases and human ecology in relation to the food supply. To say that the full reports are not easy reading for those with limited knowledge of these subjects would be an understatement. This handbook sets forth the specific recommendations for nutrient intakes made by the expert groups and aims to provide commentary written in language more readily understandable to food administrators, agricultural planners, and applied nutritionists. It should prove useful to teachers in secondary schools and colleges and to many others concerned with health education.

Natural Poisons: Chapter 26 from Official Methods of Analysis of the Association of Official Analytical Chemists. William Horwitz (ed.). Revised 1975. Association of Official Analytical Chemists, P.O. Box 540, Benjamin Franklin Station, Washington, D.C. 20044, U.S.A. US $4.00. 24 pp. (paperback).

Aflatoxin, the potentially cancer-causing agent formed by certain fungi that attack various oilseeds such as groundnuts and soy and their products has been a concern of the PAG for many years. During that time aflatoxin has gained the attention of more and more food scientists; increasingly more sensitive analytical methods have been developed and are being used. Measurements of aflatoxin at levels of less than one part per thousand million by thin layer chromatography are today being reported. Bioassay is another method of aflatoxin analysis also given in procedural detail in this thin but important update to the compendious AOAC Book of Official Methods, which is now in its twelfth edition and is the bible for food chemists everywhere. The present chapter covers methods for mycotoxins in addition to aflatoxin and also covers ochratoxins, patulin, and sterigmatocystin, found respectively in barley and green coffee, apple juice, and barley and wheat. It also deals with methods for paralytic shellfish toxins and phytotoxins. The manner of publication of this chapter represents a new departure for the AOAC in issuing revisions of methods as separata rather than having users of the large volume wait for a new edition to appear.

Food Composition Tables for Use in the English-Speaking Caribbean. Compiled by the Caribbean Food and Nutrition Institute (CFNI). 1974. CFNI, P.O. Box 140, Kingston, Jamaica. Free of charge upon application to the Director, CFNI. 115 pp. (paperback).

Compilations of this sort are of immense use not only to those dealing with nutrition in the given region covered but also to anyone needing to know such information with the possibility in mind of introducing foods from one region to another. The many tables in this book include some constituents not usually found in such compilations, such as cholesterol. The compilers of these tables are to be complimented on their clarity and hence their usefulness. To present so much useful data in such small a space and still maintain readability without confusion is no mean feat. It should also be noted that its publication was made possible with the support of the Pan American Health Organization and FAO.

World Protein Resources. Allen Jones. 1974. Medical and Technical Publishing Co., Ltd., P.O. Box 55, St. Leonard's House, Lancaster, U.K. £7.50. 374 pp. & index.

The author maintains there is no shortage of protein in the world but that most of the sources are unexplored or neglected. This book contains vast amounts of data on all sources of protein, present and future, including meat, fish, poultry, vegetables, cereals and microbial sources (that is single

cell protein, SCP). It relates proteins to society and gives an explanation of why there is famine in the midst of plenty.

There are also discussions on the technology and economics of protein on the global scale with descriptions of the quality and availability of protein sources. Methods of manufacture of SCP are covered, including the processes by which organisms are grown on oil, cellulose and carbohydrate. An introductory section on protein chemistry also gives data on the essential amino acids. Other features of this book are its many tables and the number and variety of statistical materials.

NEWS

Canadian Global Legume Survey

The total estimated area and production of legumes in the last decade has remained remarkably steady; reductions in Europe have been offset by increases in some of the developing countries. This is but one of the conclusions of the World Pulses Market Survey, issued by Canada's Department of Industry, Trade and Commerce and which draws on a variety of sources (including FAO for the statistic above) for its information.

Where there has been lower production it has been due to a variety of reasons, according to the report. In the European Economic Community generally, there has been a lack of guaranteed support prices, while in Greece, Colombia, Peru and several other countries the support prices for legumes have been too low in comparison to other crops. Changes in cultural practices have led to lower productions in Yugoslavia and Eastern Europe, and in Cuba and parts of the U.S.A. there has been a switch to other crops.

Higher outputs--planned or actual--result largely from either or both more land being planted to legumes, as in Central America, Brazil, Chile, Argentina, Thailand and parts of Africa or yield increase through technical aid, better farming practices, irrigation and the like; India is a good example of the latter situation.

Legumes remain a staple for the population in most developing countries and still provide the bulk of protein in the human diet in many regions. Consumption per person per year remains steady and high at 20kg or more in India and parts of Africa and Latin America. This figure is about 5 to 10kg around the Mediterranean and most of Asia, about 3 to 5kg in North America, U.K., Japan and South Africa, and about 0.5 to 2kg in most of Europe and Australia. Since 1950, a slow downtrend in consumption of legumes seems apparent in most industrialized countries.

There appears to be increasing interest in more use of dry peas, broad beans (Vicia faba) and lupines for animal feeding in response to the larger demand for feed protein caused by worldwide higher meat consumption. According to the survey, current research work on direct use of legume protein concentrates, legume flours and other legume products could open new outlets, particularly for dry peas and broad beans with increased consumption.

As for world trade in legumes, the Canadian survey concludes that Western Europe is and will continue to be the largest import market for nearly all types of legumes. Decreasing local production has created steadily increasing import requirements. Countries that were formerly net exporters of legumes, such as Yugoslavia and Greece, recently have become net importers.

Japan is the largest legume importing country outside of Europe. However, except for azuki beans and some dry green peas, Japan purchases only the cheapest supplies available. This is because Japan uses legumes primarily for paste manufacturing, where quality, shape, size or color are not as important as in most other markets.

Several African countries are expected either to export more legumes or upgrade the quality of the legumes offered to export markets or both. On the other hand, the Caribbean region and Latin America--with the exception of Argentina and Chile--continue to be deficit areas despite attempts at becoming self-sufficient. Several countries are in fact increasing imports to maintain adequate legume supplies for their populations.

Eastern Europe and the Soviet Union constitute a net exporting area of dry peas for humans and animals, as well as white beans and lentils. Although quantities available are by no means consistent from year to year, the availability of supplies from this part of the world affects price levels.

Some other conclusions of the report are: countries importing high-quality legumes generally look to the U.S.A. and Canada to provide regular supplies; most European and Japanese importers now prefer container shipment whenever the exporter can accomplish this; and interest in contract production is increasing as a result of the pulse shortage.

Although the survey is oriented basically towards Canada's legume marketing and trade, it contains a wealth of statistics and other particularized information that may be of interest to some readers. For information on how to obtain the report, "World Pulse Market Survey", write: Chief, Agricultural Products Division, Agriculture, Fisheries and Food Products Branch, Department of Industry, Trade and Commerce, Place de Ville, 112 Kent Street, Ottawa K1A OH5, Canada.

More News on back cover.

PAG GUIDELINE (NO. 16) ON PROTEIN METHODS FOR CEREAL BREEDERS AS RELATED TO HUMAN NUTRITIONAL REQUIREMENTS

Specific physical and chemical methods are described for determining protein quality and quantity suited to the requirements of field laboratories as well as to those of central laboratories engaged in screening programs. For the central laboratories, where they are appropriate and feasible, biological testing procedures are given. Also discussed are the physical and human resources needed to establish and maintain such screening programs. In addition, issues requiring further study and action are identified.

I. Background

In the course of its continuous review of efforts by agricultural scientists on a global basis to improve the nutritional quality of staple food crops, PAG's attention was recently drawn to problems encountered by cereal breeders in screening massive numbers of new genotypes for protein quality. The PAG *ad hoc* working group meeting, sponsored jointly by the PAG, the International Development Research Centre (IDRC), the International Maize and Wheat

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Improvement Center (CIMMYT), and the International Union of Nutritional Sciences (IUNS), was held from 17 to 20 April 1974 to evaluate and recommend suitable procedures for screening purposes. The meeting was held at Ciudad Obregón, Mexico, where is located the Government's Northwest Agricultural Research Center (CIANO), one of the sites of CIMMYT's extensive cereal breeding program. An additional drafting session was held at the PAG Secretariat in New York 4 and 5 September 1974. The members of the working group and their affiliations are listed in Appendix I.

II. Introduction

Cereal breeders in many parts of the world are currently working to develop new cereal varieties with improved agronomic characteristics that will be reflected in higher grain yields. Since cereals are also a major source of protein, the breeders also must seek to improve the quantity or quality or both of the protein in the grains; in the process, they may need to screen many samples. Improved protein characteristics cannot be found by merely looking at the seeds, so breeders must rely on chemical evaluation of early breeding lines and on both chemical and biological evaluation of more advanced lines.

The working group benefited from visits to CIMMYT's breeding, evaluation and testing facilities and from discussions with their scientists. Useful data were available to the group on programs at CIMMYT and IRRI including information on the critical stages of breeding at which selections must be made, the size and number of samples to be evaluated and the speed with which the evaluations must be carried out. The meeting was also guided by background documents which are noted in the list of references.

Collectively and in specialist sub-groups the participants reviewed a wide range of chemical and physical methods for analyzing total protein nitrogen and specific amino acids, particularly lysine, as well as the various biological and microbiological methods for evaluating cereal proteins for their potential value in human nutrition.

The conclusions and recommendations of the working group constitute the main body of this guideline. It is anticipated that these recommendations will be studied seriously by scientists in international and national cereal improvement programs and also by those in food and nutrition programs whose concern embraces the major cereal crops. The recommendations will hopefully lead to greater standardization of methodology in the analysis and evaluation of cereal crops through the interest and support of the relevant international scientific unions. This guideline should encourage more cooperation and coordinated effort among all international scientists seeking to improve the productivity and nutritive value of cereal crops.

It should be emphasized that this guideline represents only the beginning of what must become a continuous review and updating of screening methodologies for cereal breeders, since the field is advancing rapidly. It is recognized that other competent groups are also evaluating and recommending crop screening procedures. Particularly noteworthy is the program of the Joint Food and Agriculture Organization/International Atomic Energy Agency Division of Atomic Energy in Food and Agriculture.

III. Significance of cereal grains in human nutrition

Cereal grains contribute more than any other single group of food staples to both calories and protein in the human diet. In its major document on world agricultural development plans, published in 1969, the FAO stated that cereals, particularly wheat, rice, maize, sorghum, millet and barley, provided more than 50 per cent of calories and protein for the people of Africa south of the Sahara, more than 60 per cent of calories and protein for the peoples of Asia, and more than 65 per cent of calories and protein for the Near East.

In Central America maize provided 57 per cent of the daily intake of calories and 45 per cent of the daily protein for the adult population (17).

Although it seems on first glance that on a global basis the annual per caput cereal production is increasing at a slightly faster rate than world population (at least it so appeared prior to 1972), the statistics in a number of developing countries are misleading as to the actual trends, which have consequences in terms of human nutritional status. In fact, the greatest increase in cereal production and consumption has been in the economically developed countries where most of the grain is fed to animals. For example, although in the U.S.A. the per caput consumption of cereal grains is more than 900kg per annum, the average amount directly consumed by humans as cereal foods is only about 50kg. The other 850kg is used for production of meat, meat by-products, dairy products and eggs as well as for making alcoholic beverages. In India, by comparison, per caput consumption of cereals is hardly more than 170kg per annum, but most of this is eaten directly as cereal foods.

IV. Why the nutritional quality of cereal grains must be improved

Most common varieties of cereal grains are deficient in certain essential amino acids, lysine being most often the first limiting amino acid. The amino acid deficiencies of the subsistence food grains in the traditional diets of many nations are to some extent compensated by food legume proteins. For example in Southeast Asia, soybeans and mung beans supplement the rice staple; in Africa, cowpeas and pigeon peas supplement sorghums and millets, while maize and beans are a familiar dietary combination in Latin America.

Notwithstanding the recognized need to substantially increase production and consumption of food legumes, since these constitute some of the cheapest and most appropriate sources of protein, cereals will continue to provide an important proportion of the protein consumed by the majority of the world population. Consequently, in any major international cereal breeding program, attention must be given not only to the quantitative aspects of cereal production but also to aspects of protein nutritional quality, in the same way that it is needed for the improvement of food legumes (12, 39, 45) as well as some of the other crops that are regionally significant as food staples, such as teff (Eragrostis tef) grown in Ethiopia, and quinoa (Chenopodium quinoa) cultivated in Peru and Ecuador.

V. Priorities of the cereal breeder

One of the main factors of the world food problem is the shortage of food, and therefore of food energy. For the poorer segments of the population, lack of purchasing power to acquire sufficient quantities of food is the major problem that worsens in times of global food shortage. It is thus understandable that cereal breeders have given primary attention to those characteristics that are of greatest importance economically and in terms of increasing the food supply. In view of future world needs, they should be encouraged to select for: a) increased yield of food energy per hectare; b) equivalent or increased yield of available protein per hectare; c) varieties in which yield is improved with or without intensive fertilization and irrigation; d) improved essential nutrient content per 1000 Kcal.

Cereal breeders and agricultural scientists from a number of other disciplines have used the world collection of the various cereal grains as a source of the genetic heterogeneity necessary for attaining their aims for improving the productivity and agronomic properties of these crops and their resistance to microbial pathogens and insect pests. In addition, they have selected new genotypes to meet other criteria: for wheat, improved technological properties such as milling and baking properties; and for rice, improved cooking characteristics, color, texture and flavor. In recent years, these plant breeders have become more attentive to the need to

improve the nutritive value of the cereals of concern to them. These scientists are very much aware that in any early crop selection a preliminary genetic "signal" that may indicate an unusual or improved nutritional trait must be verified by further propagation and rigorous testing to insure that the improvement is real and not simply a product of local environmental factors.

It is commendable that many modern cereal breeding programs routinely analyze new cultivars for protein quantity regardless of the purpose (e.g. improved yield, insect or disease resistance, milling and baking properties, etc.) for which the new variety was originally selected. However, breeders must not take for granted that favorable routine test results for protein quantity assure favorable protein quality nor that the protein is indeed utilizable nor even that nutritionally deleterious substances are absent. Thus a protein quality screening test must be considered to be an important part of any effective breeding protocol applied to cereal grains or other staple food crops. As will be detailed later in this guideline, cereal breeding programs may be directed at increasing either the quality or quantity of proteins. A net increase in protein nutritive value may result from an increase in one of these parameters even if there is a small decline in the other as, for example, has been observed to be the case for rice (26). Notwithstanding, protein supplies cannot be extended by maximizing utilizable protein in the grain since people cannot be expected to reduce their consumption of improved varieties of the grain to levels that meet their protein requirements. In actual practice, cereals are consumed mainly for providing energy.

If the scientific literature is a reliable guide, cereal scientists have in the past given more attention to the interests of the processor - the miller, the baker, the animal feeds manufacturer - than to the problems of the cereal plant breeder. Although a number of cereal breeding programs carry out screening with a view to improving the processing and food-use properties of the grain, many of the widely accepted methods of cereal analysis are, even for these purposes, too slow, too expensive and too demanding of sample material to be useful to the cereal breeder who is obliged to select superior strains from very limited quantities of many thousands of breeding lines and to make such selections quickly and accurately.

VI. Breeding for nutritional improvement

A breeding program designed for improving the nutritional value of cereal proteins must also be capable of quickly identifying the desired genotypes, in this case those having an inheritable potential for higher endosperm protein or for protein of superior nutritional value in terms of its amino acid composition or for both. The task must be accomplished with early generation material when sample quantities are often severely limited.

Except in a few instances, cooperation between cereal plant breeders on the one hand and analytical chemists and nutritionists on the other has not been as well integrated as desirable for realizing major improvements in the nutritive value of cereals. Chemists and nutritionists are becoming aware of the scope and magnitude of modern cereal breeding programs and are now training their attention on the considerations involved in selecting from massive collections of breeding material.

During the working group's discussions, the critical stages of selection of successive generations of genotypes (F_1, F_2, F_3, etc.) at which evaluations need to be made in a typical large-scale program were described by the CIMMYT and IRRI scientists. They also indicated the number of samples and the quantity of each sample that can be expected to be available from a breeding program of the scale being carried on by CIMMYT. These are summarized in Table I.

Table I.

State and Amount of Material Available for Seasonal Selection of Early Generation Lines in Large Scale Breeding Programs*

Stage	No. of samples per crop stage	Seed quantity per sample
Parental lines	1,500	Large quantities, 1-5 kg
Succeeding Generations		
F_3 seed coming from F_2 plants	10,000 to 12,000	5g from individual plants
F_4 seed	about 8,000	5g from individual plants
Advanced lines: F_5 and onwards	about 1,000	Large quantities, 1-5 kg

*Magnitude typified by CIMMYT program.

The CIMMYT scientists also pointed out that they must screen as many as 500 additional samples each year from other sources. In a breeding program such as that of CIMMYT, promising new genetic material selected by chemical methods should be biologically evaluated only at more advanced generations, such as F_5, when adequate amounts of material are available and the number of samples to be tested is manageable (see Figure 1). Sufficient material would normally be available to permit biological testing of parental stocks.

Due to the relatively short elapsed time in some breeding programs between one harvest and the next planting, there is an absolute need for both speed and efficiency in making the tests necessary to the evaluation of segregating material of various crops. For example, due to the favorable climatic conditions obtaining in Mexico, the CIMMYT group is able to grow two generations of cereal crop-breeding material per year, an advantage not available to all breeders. However, this leaves them with only about three weeks in which to make the necessary selections for re-planting. Breeding programs in other parts of the world are exploring the implications of such situations to the expansion of multiple cropping systems.

VII. Considerations determining selection and application of chemical and physical screening methods

The working group concluded on the basis of its collective experience that the suitability of chemical and physical screening methods for the preliminary assessment of protein quantity and nutritional quality in cereals must be related to two levels of need. The first level is in the relatively small field testing laboratory with limited facilities, which although lacking in capabilities for sophisticated analytical techniques can nevertheless identify the most promising genotypes in from a few hundred to a few thousand samples annually. The second level is in larger, well-equipped central testing facilities such as those operated by the international agriculture research centers where thousands of samples must be analyzed more comprehensively.

There is a substantial volume of literature related to the chemical and physical analysis and the biological evaluation of cereals. Reviews of this literature have been presented by Kaul (31), McLaughlan and Campbell (34), Munck (43) and others. However, not all of

the tests proposed are suited to the needs of the plant breeder screening many hundreds of breeding lines.

With these considerations in mind, the working group recommended only those tests they felt would best suit the cereal plant breeders, taking into account different levels of analytical capability. Tests were selected with due regard for the speed and the level of accuracy necessary and the number and size of samples available at various stages in breeding programs.

Thus, the group proposed two separate analytical protocols embodying pertinent methods, the first for evaluation of early generation material and the second for testing of more advanced generations where larger quantities of material were available. Literature references to the recommended methods accompany discussions of the procedures.

VIII. Considerations in selecting biological procedures for nutritional evaluation

A. General considerations

The primary objective of biological assays aimed at nutritional evaluation of protein quality is to predict the value of the material as a source of nitrogen and of essential amino acids for the species for which it is intended. Many methods are available for ranking protein sources according to their relative nutritional quality, but most of these methods fail to adequately predict their nutritional value as sources of protein for meeting human protein and amino acid requirements. Thus, a number of considerations must be weighed when formulating recommendations on biological methods to be employed in a cereal breeding program aimed at improving the human diet.

It is important that tests must be conducted under highly standardized conditions and must provide a measure of the maximum protein nutritive value of the whole grain when it is consumed as the sole dietary protein source. Ultimately, it is necessary to assess the protein nutritional value of a cereal in the form and dietary proportion in which man consumes it, usually in a mixed diet. Such a complete survey of the human nutritional significance of a cereal protein does not fit easily into a cereal breeding program.

At the present time protein quality evaluation uses as a working hypothesis the premise that in most situations the nutritive value of a protein can be explained by the distribution pattern and availability of the amino acids it contains. Hence, all meaningful measures of the protein quality of food for human consumption should be related to the total protein and amino acid needs of man. Only those methods that have been evaluated in terms of this relationship can be recommended for general application in plant breeding programs.

The choice of which biological method to use depends on the point in the breeding program at which they should usefully be introduced and the number and size of cereal samples presented for testing. Reliable biological methods require more sample material, time and expense than chemical methods.

It is worthwhile to emphasize briefly the significance and major limitations of methods for the biological evaluation of protein quality for use in a cereal breeding program. First, the methods are inherently more variable than chemical methods, and particular care must be taken in carrying out bioassay procedures. A minimum requirement for obtaining satisfactory data is the use of a carefully supervised animal facility as well as the participation of a nutritional scientist familiar with the conduct of the tests. Second, the biological evaluation of a food protein source is complex since the whole organism may respond to various dietary and environmental influences that exist during the test period. Thus, in some instances, estimates of low-protein quality may be due to dietary factors

other than nutritive value of the test protein per se, and these factors must be considered when interpreting results obtained in the bioassays.

B. Chemical vs. biological evaluation of protein for nutritional quality

The three major factors that influence nutritional value of a cereal as a protein source are: a) quantity of protein; b) quality of protein; and c) digestibility of protein and biological availability of the amino acids. For all cereal proteins the first limiting essential amino acid is lysine and for most, the second is threonine. In the case of maize, the second limiting amino acid is tryptophan.

Assays for total protein content and the limiting amino acid are recommended as the best practical approach for estimation of nutritional value at early and intermediate stages of development of a cereal breeding program. Determination of the complete amino acid profile would be of secondary significance at this stage of a breeding program, unless the laboratory is already equipped to perform automated gas-liquid or ion exchange chromatography on a routine basis.

Many studies have confirmed the general validity and utility of chemical methods for evaluating the potential nutritive value of a protein source for humans (4, 7, 20, 36). There is generally a good correlation between the prediction of the nutritional value of unprocessed cereal protein sources based on chemical evaluation and the nutritional value of the proteins as determined by bioassay procedures (4, 36). In cases where the correlation has proved to be less than satisfactory, the materials tested have usually been commercial animal feeding stuffs, or foods which have been changed by processing or heating (4, 36). There is also some indication that a chemical forecast of protein quality does not adequately predict the nutritional value of sorghum; the reason appears to be related to the presence of polyphenolic substances (tannins) in some sorghum varieties (28). When chemical methods are available for identification of such nutritionally related factors it is possible to predict which samples will likely yield a low nutritive value. Clearly, with materials of this kind the chemical evaluation of a protein source should include an assessment of constituents that modify the nutritional response in the whole organism. Apart from these limitations, the chemical approach is a highly useful procedure, and the relevance of the chemical method to human nutrition can be further strengthened by reference to the section below on biological methods.

C. Biological methods for protein evaluation

When new cereal lines reach an advanced stage of development, a biological evaluation of the cereal protein should be conducted. Parental lines and new species for which nutritional information may be unavailable should also be studied for their nutritional value by the method(s) outlined below.

Biological methods for the assessment of protein quality indirectly or directly measure body protein content changes in response to the ingestion of the test protein by the test animal. Since the direct measurement of body protein is more complicated and involves additional sampling and measurements, all of which contribute to error, the measurement of changes in body weight will generally provide an adequate estimate of changes in body protein content. When young rats are fed diets varying in protein content, there is evidence to indicate that the measure of change in body weight is a fairly good estimate of the change in body protein (44).

Several recent reviews have considered the features and limitations of the various bioassay procedures (24, 33, 34, 44). Many of the methods that have been in common use, such as the protein efficiency ratio (PER), net protein ratio (NPR), net protein utilization (NPU) and biological value (BV), have been useful in the past and often classify different

proteins in order of nutritive value. However, they are not recommended for general use in a plant breeding program because they do not provide accurate indices of nutritional differences among proteins of differing quality, with the possible exception of rice (26). This is especially the case for PER. For example, there is no proportionality among PER values: a PER of 2.0 does not mean that the protein possesses twice the nutritive value of another protein with a PER of 1.0. The shortcomings of the PER method have been adequately discussed by several authors (24, 33, 34). Despite its apparent simplicity and widespread use, PER cannot be recommended as a critical method for the evaluation of protein quality in cereal grains.

The most reliable biological assay for protein evaluation is one based upon the estimation of changes in body protein content or in body weight to given protein intakes over a range in which the response is linear and directly related to the nutritional requirements of the organism. The assay that meets these criteria is the relative protein value (RPV) method, as described in section X. B. of this guideline. This assay compares the rate of body weight change of animals fed various levels of a test protein with the rate of weight change observed in animals fed similar levels of a "reference" or "standard" protein. The RPV assay requires testing at several levels of dietary protein in order to determine the slope of the line of body weight gain in response to increasing intakes of test protein.

D. Choice of test species

There are a number of studies demonstrating that the nutritive values of proteins as determined by feeding to weanling rats under specified conditions are in close agreement with results obtained in human subjects (8, 10, 56). These observations support the use of the rat for the biological evaluation of protein, and this species is recommended for bioassay procedures in plant breeding programs at this time.

Various other animal species have been used in protein biological assays including small animals such as the chick, mouse and meadow vole (21, 32, 42). These species offer the potential advantage that they require less sample than is needed in rat bioassays. However, neither the mouse nor the meadow vole can be recommended as a test animal for the biological evaluation of cereal protein at this time. The chick cannot be recommended as a test species because its amino acid requirements are very different from those of man.

Bacteria, protozoa and insects have been used in studies of protein evaluation (23, 47). However, the methods employing these organisms have not been adequately standardized, so they cannot be recommended in cereal breeding programs at this time.

Larger species such as the pig and dog may provide results meaningful for human nutrition, but they are not generally suitable for plant breeding programs because of the expense involved and the amount of feeding material required.

IX. Specific procedures recommended for chemical evaluation of early generation and more advanced genetic material

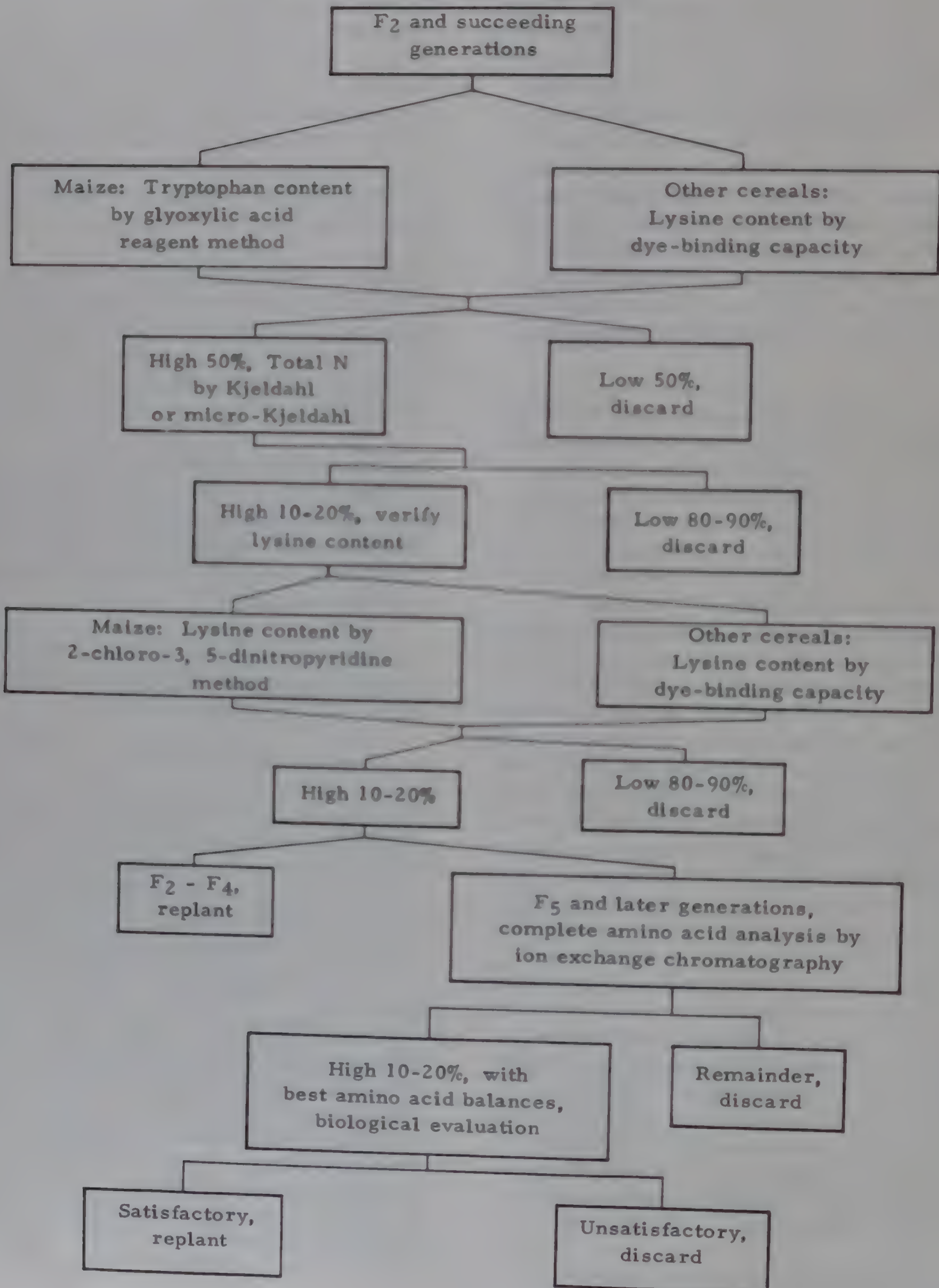
A. General considerations

The systematic approach recommended for evaluation of cereals in breeding programs is predicated on the necessity to screen very large numbers of genotypes in a short period. The overall system is summarized in Figure 1, which is a schematic diagram of the recommended screening and evaluation procedure.* Under such a system, the choice

*Other scientists suggest that early generation material, F_2 and F_3, should be selected primarily on the basis of grain size and yield as well as other agronomically desirable characteristics. According to them, there is good correlation between grain weight and the total amount of protein per grain. They feel that only lines F_4 or even F_5 onwards need be tested for protein quantity and quality.

Figure 1.

Schematic representation for screening cereal grains for protein content and nutritive quality



of tests, the order of tests in the screening procedure and the arbitrary cut-off points recommended are of themselves important. For example, screening by means of the dye-binding capacity (DBC) for basic amino acids before assaying for total protein will eliminate about half the samples, thereby halving the number of protein assays needed. Similarly, a screening test that detects low tryptophan lines of maize will automatically eliminate the need for testing a large proportion of the material for lysine, because the content of tryptophan, the second limiting amino acid in maize, has been shown to be closely related to lysine, the first limiting amino acid.

It is recognized in plant breeding that rapid, large-scale, screening techniques may result in the discard of some lines with possibly useful characteristics. However, the need to save time and money more than justifies the relatively small amount of genetic material sacrificed in this manner.

Literature references are given to the specific analytical techniques recommended by the working group. Where necessary, the underlying principles of the tests are briefly described. Advice on equipment suitable for use in screening laboratories may be obtained on request from members of the working group.

Certain crops, for example maize, sorghum and oats, require specialized analytical treatment, due to oil and pigment contents higher than most other cereals. In the case of maize, the oil interferes with certain extraction procedures and may also cause excessive frothing, e.g. during the digestion step in the micro-Kjeldahl analysis. Any pigments present constitute a source of error in certain colorimetric tests. Most of these interferences can be minimized by extraction with a non-polar solvent.

In certain instances it may be necessary to store samples while they await analysis. Inadequate storage, especially at high temperature and humidity, may lead to loss of valuable genetic material through chemical and biological changes. Deterioration by bacteria, fungi and insects must also be prevented. Problems encountered in the storage of cereal grains are well covered in a recent monograph on the subject (11). Efficient aeration is necessary for the prolonged storage of any plant material; refrigeration, even if it is only partial, e.g. to 15° C. (60° F.) is recommended wherever possible.

B. Recommended procedures for chemical and physical evaluation

1. <u>Tests recommended for field laboratories</u>

a. Sampling and sample preparation

In the case of wheat, barley, triticale, and rice, a representative sample of not less than 5g is blended, air-dried and provided to the laboratory. This is the <u>least amount</u> of sample required and is important in the case of early generation materials up to F_4, when only minimal quantities of grain are available. For screening tests conducted on early generations, moisture content need not be determined unless precise comparisons are to be made with data from other laboratories, or when publication requires such values to be quoted.

Figure 1.

The chemical methods given in the diagram, with the exception of ion exchange chromatography (IEC), are keyed to the capabilities of small field laboratories. IEC and biological evaluation are procedures recommended for large central laboratories, which would also employ certain more automated methods for some of the chemical tests, according to the equipment they own. (See text.)

The Udy or Weber cyclone mills are recommended for the grinding of these caryopsis-type seeds. Due to their higher oil content, maize, sorghum and oats tend to clog grinders of this type. These grains may be ground in any suitable impact mill, such as the Krups Model 75, the Moulinex mills or even a hand grinder. After grinding prior to analysis, the ground material may be defatted with solvents such as hexane or petroleum ether, a procedure that also helps remove pigments that may interfere with some colorimetric tests (49). Further reduction in particle size may in some cases be advisable after defatting. The above impact mills are recommended for this purpose. For maize specifically, the reader should consult CIMMYT Bulletin No. 20 (49).

b. Preliminary quality screening tests

i. Dye-binding capacity, DBC (41)

A solution of the acid diazo dye, Acrilane Orange G* is mixed with the ground sample. The dye is bound quantitatively by the basic imidazole, guanido and amino groups of the protein, which occur in the polypeptide chain on histidine, arginine and lysine, or as free terminal groups. The unbound dye remaining in the solution is measured colorimetrically after filtration or centrifugation. Since the proportions of basic amino acids and terminal groups are reasonably constant in cereal proteins, the correlations between DBC and total protein content are high. However the level of lysine and arginine is increased substantially in high lysine cereals, and the differing ratios of DBC to protein can be utilized to select these genotypes. The chief sources of error in DBC testing have been discussed by Williams (54). In addition, the presence in the test material of excessive chlorophyll, fiber and certain tannins can give rise to erroneously high DBC values.

*Also known as Orange 12 (CI 15970), chemically as 1-phenylazo-2-naphthol-6-sulfonic acid, monosodium salt.

Different lots of dye may differ slightly in color intensity due to batch-to-batch variability; the dye should be standardized before use. The method of Mossberg is recommended for DBC (41). Samples of early generation material showing low DBC values may be eliminated, whereas those showing satisfactory values (e.g. the samples that show values higher than the arbitrarily set cut-off point) should be further analyzed for total protein and lysine by more specific methods, as outlined in Figure 1.

ii. Ninhydrin screening method

It has been shown that high lysine mutants such as opaque-2 maize (37), high lysine sorghum (46) and mutant 1508 barley (27) contain unusually high levels of free amino acids. The presence of abnormally high levels of free amino acids may therefore be regarded as indicative of above average levels of lysine. Ninhydrin reagent reacts with the alpha amino groups of free amino acids to form a colored complex, the intensity of which is proportional to the concentration of total free amino acids (38). As an alternative to the DBC procedure this test may be applied either to a sectioned surface of single kernels or to an extract of the pulverized grains. The sectioning technique is non-destructive, in that the portion of the kernal with the embryo intact may be planted and grown. The non-destructive feature of this test recommends its use for preliminary field testing. When screening for high lysine mutants, comparisons should be made using controls with "normal" levels of lysine.

iii. Lysine and tryptophan

These colorimetric procedures are significant primarily for maize (49). Lysine and tryptophan are present in a roughly constant ratio of 4:1. Consequently when tryptophan is determined, an estimate of lysine is furnished. The defatted, finely-ground endosperm is digested with papain to release the amino acids. The tryptophan color is

developed by means of reagents that when combined produce glyoxylic acid (Fig. 1) (14, 49). In the case of lysine, the papain digest is treated with a solution of 2-chloro-3, 5-dinitropyridine (DNP, Fig. 1) (49).

iv. Total protein

The micro-Kjeldahl procedure is described in the latest editions of the analytical testing methods manuals of the Association of Official Analytical Chemists (3) and the American Association of Cereal Chemists (1) as well as in CIMMYT Bulletin No. 20 (49).

v. Verification of high lysine

Samples that indicate DBC values higher than the cut-off point should be tested for total protein (Fig. 1). These samples should then be reanalyzed for DBC on a constant protein basis. Samples are weighed to give a constant amount of protein, e.g., 60 mg. and tested again by the DBC technique. The results of the DBC retests are then plotted against the total protein content of the original samples, at which time any segregates having retested DBC values that are significantly above the slope of the regression line (the "line of best fit") will indicate samples with an above average level of lysine. Figure 2 illustrates a typical DBC retest versus total protein plot. The plot was made by Munck and demonstrates the striking deviation of the high lysine barley mutant, Hiproly (43).

2. Tests recommended for central laboratories

a. Sampling and sample preparation

The considerations discussed under this heading in the previous section are applicable to both field and central testing laboratories. However, due to the increased complexity of testing in central laboratories, more than 5g of grain may be needed for screening F_5 and later generations.

b. Total nitrogen

i. Protein quantity based on the determination of total nitrogen

The micro- and macro-Kjeldahl methods are recommended for total N (1, 3, 13, 15, 49). In the case of the micro-Kjeldahl test, the digestion is the critical step. Block digestors may be employed, but they may require evaluation for uniformity and efficiency of digestion. Such an evaluation has been carried out by Wall et. al. (50). The final analysis on the diluted agents may be conducted volumetrically or colorimetrically either by standard or automated colorimetry. Ammonia in the Kjeldahl digest reacts quantitatively with either sodium phenate hypochlorite (15, 22), salicylate dichloroisocyanurate (13, 52), or Nessler's reagent (53) to form stable colored complexes.

c. Specific amino acids

i. Methods of hydrolysis

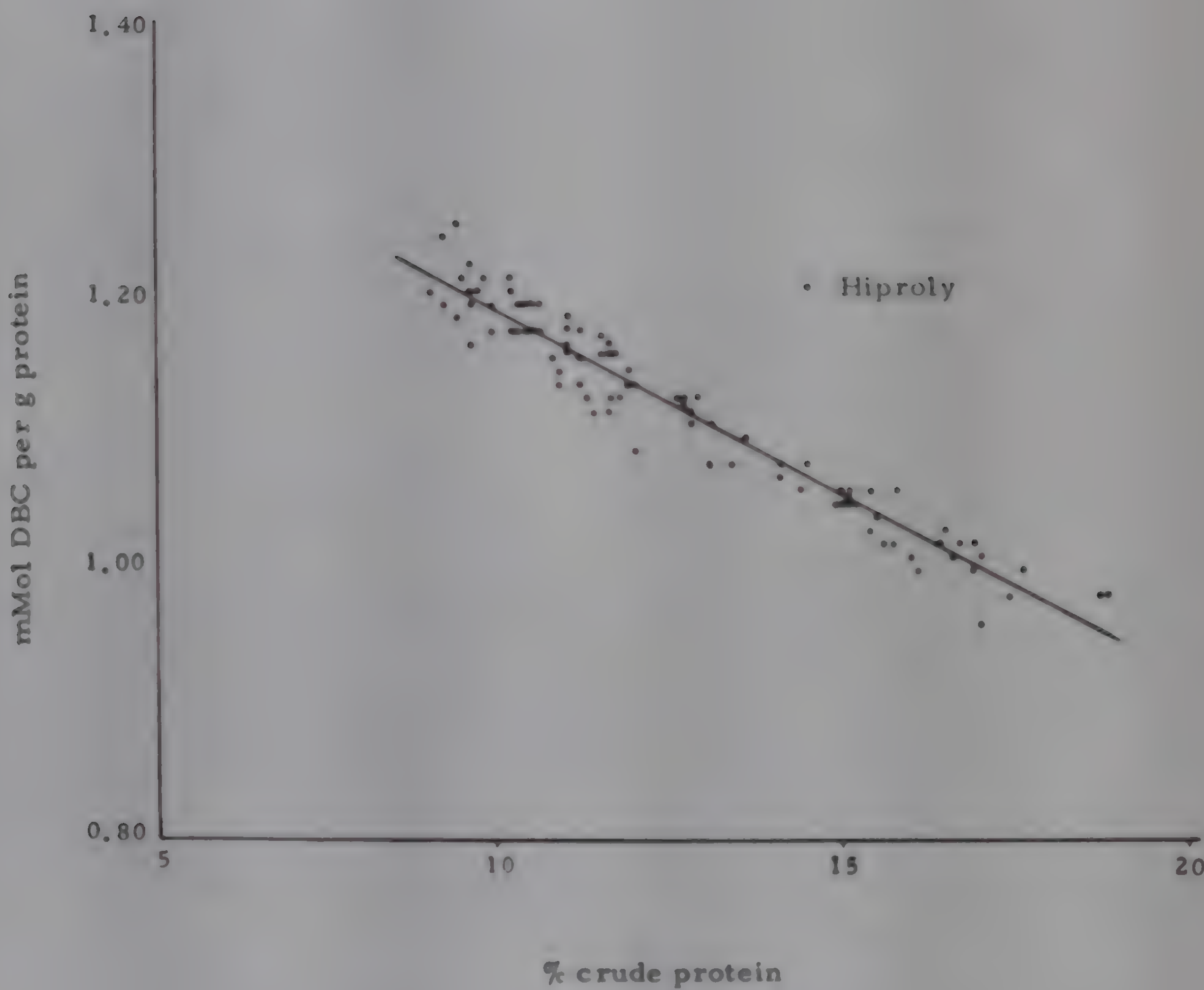
Efficient hydrolysis of proteins is absolutely necessary for accurate amino acid analysis. Some amino acids may be destroyed or modified during hydrolysis, while others may not be completely released. The recommended procedure involves hydrolysis with 6N hydrochloric acid for 18 - 24 hours at 105° C. - 110° C., with suitable precautions to maximize recovery and minimize degradation (6, 48).

ii. Chromatographic methods

The determination of amino acids by classical ion exchange chromatography (IEC) is based on the elution after hydrolysis of the amino acids from an acidic cation exchanger, using a pH and buffer concentration gradient. The amino acids in the eluate are measured colorimetrically after reaction with ninhydrin. A variety of excellent automated instruments is available. In view of the wealth of literature and accumulated experience in the field of IEC, use of this technique is recommended

Figure 2.

Example of plot for verification of high lysine



Normal lysine and high lysine samples can be differentiated by plotting % crude protein (in this instance N x 6.25 was used) vs. dye-binding capacity (DBC) of samples weighed on a constant crude protein basis; here each DBC sample contained 60 mg. crude protein per 20 ml. dye solution. In this plot, Hiproly barley, a high lysine mutant, stands out from the normal strains (43).

at this time. The method permits either the simultaneous analysis of all naturally occurring amino acids or of a single amino acid. For example, a rapid IEC method for the determination of lysine has recently been described (35).

3. Alternative test procedures

The working group judged that the test methods recommended above constitute both simple and more refined techniques that have repeatedly demonstrated their economy, accuracy and reproducibility. These tests may at this time be regarded as the most suitable for the purpose of screening. However, there are available several alternative procedures that are suitable provided that the screening laboratory can bear the expense of purchasing and maintaining specialized equipment and of supplying the necessary chemicals. Furthermore, although some of these alternative procedures have been painstakingly tested in the laboratories where they were developed, many require additional adaptation for use under other conditions. Under these circumstances, it is felt that the following tests should be considered as likely to prove themselves as valuable additions to screening and evaluation methodology for the future:

a. Total protein

i. Infrared reflectance spectroscopy, (IRS) (55)

Infrared reflectance spectroscopy (IRS) equipment can be used to determine protein (and oil and moisture, if necessary). No chemicals are used in the procedure. With present equipment it is possible for one technician to perform over 200 tests in a seven-hour working day on prepared samples, with an accuracy satisfactory for screening.

ii. Biuret procedure (29)

This procedure has been extensively and favorably evaluated over the past twenty-five years, and has proved itself useful in several laboratories. Variability in chemicals together with the possible occurrence of turbidities prior to colorimetry represent sources of error in this procedure. In addition, opaque-2 maize gives a reduced color response when compared with normal maize (40).

b. Lysine

i. Lysine decarboxylase test (51)

This test is based upon the colorimetric measurement of carbon dioxide which is specifically released from lysine by the enzyme lysine decarboxylase. The test as described provides a rapid, accurate and precise automated analysis for lysine, and thirty samples per hour can be analyzed. A carbon dioxide gas dialysis membrane is used in the automated system.

c. Total amino acids

i. Gas/liquid chromatography (GLC) (2, 30)

Amino acids are quantitatively converted to volatile derivatives that are then separated by programmed-temperature gas chromatography using flame ionization detection. For laboratories that already possess or contemplate the purchase of a gas chromatograph, this procedure will merit investigation. Although complete hydrolysis of the protein remains a prerequisite for this technique and the procedures for preparing volatile derivatives constitute a possible source of error, methods have been developed and information has been given on hydrolysis, ion exchange cleanup, derivitization and quantitation that can make GLC equal IEC in precision and accuracy (30).

4. Expression of analytical values

a. Protein

It is the custom to convert "nitrogen" as determined by Kjeldahl methods to "protein" by multiplying by a standard factor. The factor varies according to the protein source, and the reader should consult the appropriate

reference for a listing of factors specific for various materials (20). It is recommended that "protein" values should be quoted as total nitrogen, or alternatively as protein on a dry weight basis, provided that the conversion factor is clearly stated. As already suggested, at field screening laboratories, protein may be recorded on an "as is" moisture basis, since moisture content will probably not differ greatly among air-dried samples grown and stored concurrently at the same location. However, when cited in the literature the results should be stated on a standard moisture basis, and zero moisture is recommended.

b. Amino acids

In view of the general acceptance in the literature of human nutrition of the expressions mg AA/g protein and mg AA/g nitrogen, the working group recommends the use of either when relating amino acid values to human needs.

However, it has long been the custom to express amino acid analytical values as g AA/100g protein (dry weight basis with conversion factor given), which continues to be generally used by plant breeders. In the case of complete amino acid analysis, the use of this expression permits easy checking for total recovery of amino acids. When calculating total recovery by adding the weights of the individual amino acids, allowance should be made for the elements of water added during hydrolysis. When peptide linkages are ruptured during hydrolysis, the elements of water are added to the amino acids thereby freed. As a result, the combined weight of the free amino acid molecules will be higher than that of the protein molecules from which they were freed. Thus, from an initial 100g of protein an appreciably greater weight of amino acids, approximately 116g, will be recovered after hydrolysis. Accordingly, amino acid recovery should be calculated and reported.

c. Other considerations

Protein content and composition vary among different fractions of a cereal grain. Protein as per cent dry matter is influenced by seed weight and the relative proportions of the various seed fractions present. These in turn are influenced by environmental and agronomic conditions. Some plant breeders, therefore, prefer to select for high protein genotypes on the basis of nitrogen content per seed rather than protein as dry matter. If the more conventional term, "protein as per cent dry matter" is to be used, information must be provided as to the kernel characteristics, including the average weight of a single grain. Shrivelled or malformed kernels may possess an inordinately high ratio of seed coat to endosperm with a consequently higher protein and lysine content expressed on a dry weight basis. For purposes of comparison, additional data should be included as to the protein content and kernel characteristics of standard varieties, or genotypes used as parental material for the lines derived. For example, in the case of triticale, data should be included which relate to the *Triticum* and *Secale* parents.

5. Collaborative studies

Continuing collaboration is necessary between field and central laboratories to critically review analytical procedures, in order to insure that methods and equipment used by each laboratory are adequately standardized and provide concordant results. The international agricultural research centers should be encouraged to collaborate with each other and with appropriate international scientific unions and other technical societies and university and industry laboratories in order to constantly improve commonly used chemical, physical and biological methods and to develop new techniques with superior speed, accuracy and reliability. These institutions and organizations are listed in Appendix II.

The Joint Food and Agriculture Organization/ International Atomic Energy Agency Division of Atomic Energy in Food and Agriculture, based on its sponsorship of relevant conferences and research, publishes valuable material relating to screening methodologies and programs (31). The International Association for Cereal Chemistry (ICC) has received recommendations that it should concern itself with development of analytical procedures useful for cereal breeders.

a. Procedure for a network comprising central and field laboratories

i. Checking the accuracy of individual laboratories

The central laboratory carefully prepares samples and analyzes them for a primary constituent important in the field laboratories' quality screening programs. Samples of this type are distributed from time to time to a number of collaborating laboratories who are instructed to carry out a prescribed number of analyses for the selected constituent using the technique normally employed. Such studies will identify laboratories whose results differ significantly from the mean. The reasons for discrepancies can then be sought and corrected.

ii. Standard procedure check

Several check samples are prepared and sent to collaborating laboratories with instructions to follow a set procedure. It is very desirable to supply uniform reagents - especially dyes - since they can vary among different sources and, in some cases, among batches from a single source. Collaborative studies, as described, assist greatly in the monitoring of reproducibility among the group of laboratories, and are also useful in gaining information and experience on new techniques.

X. Specific procedures recommended for the nutritional evaluation of protein quality

A. Predictive method - amino acid score

An amino acid score can be calculated when both total nitrogen or protein, and the concentration of the first limiting amino acid in the cereal are known. The amino acid score provides a chemical prediction of the nutritive value of a protein. The score is a comparison of the level of the first limiting amino acid in the test protein with the level of the same amino acid in a reference pattern of amino acids. The pattern that should be used is the 1973 joint FAO/WHO provisional reference pattern (20). This pattern, shown in Table II, is derived from estimates of the amino acid requirements of young children.

The amino acid score (formerly known as chemical score) is calculated as follows when the limiting amino acid is known:

$$\frac{\text{content of limiting amino acid in the test protein}}{\text{content of the same amino acid in the reference pattern}}$$

When the complete amino acid profile is known or if the limiting amino acid is uncertain, the chemical score is calculated as follows:

$$\frac{\text{content of amino acid in the test protein}}{\text{content of same amino acid in reference protein}}$$

The lowest score obtained for any of the essential amino acids of the test protein may be taken as a first approximation of the probable efficiency of its utilization by children. Table II gives the calculated scores of the essential amino acids of several cereals.

Table II.

Amino acid scores calculated for selected cereals

Amino acid	Scoring pattern amino acid levels	Whole wheat		Wheat flour (60-70% extraction)		Maize		White rice		Sorghum	
		Amino acid content mg/g N	Amino acid score	Amino acid content mg/g N	Amino acid score	Amino acid content mg/g N	Amino acid score	Amino acid content mg/g N	Amino acid score	Amino acid content mg/g N	Amino acid score
Lysine	340	179	53	113	33	167	49	226	66	126	37
Threonine	250	183	73	153	61	225	90	207	83	189	76
Methionine and Cystine	220	253	115	229	104	217	99	229	104	181	82
Leucine	440	417	95	400	91	783	178	514	117	832	189
Isoleucine	250	204	82	217	87	230	92	262	105	245	98
Valine	310	276	89	240	77	303	98	361	116	313	101
Phenyalanine and Tyrosine	380	469	123	423	111	544	143	503	132	473	124
Tryptophan	60	68	113	58	97	38	63	84	140	63	105

Scoring pattern amino acid levels are those suggested by the FAO/WHO joint committee (20). Amino acid levels of cereals are from FAO data (19).

B. Relative protein value (RPV)

1. Principle

The relative protein value (RPV) method is recommended for the biological evaluation of advanced lines. In this assay the rate of body weight change of rats fed various levels of the test protein is compared with that obtained with animals fed a reference protein. This test requires that body weight response is linear over the range of test protein intakes studied. It should be noted that the accuracy of the estimate depends on number of animals used, the variation around the regression lines and the range of protein intakes included in the test. The wider the range of protein levels tested, the more accurate will be the result, providing the regression is linear. The appropriate levels of test protein to be used in the assay depend upon the quality and quantity of protein of the test material.

2. Materials

a. Animals

Weanling rats of a single strain, age 21 to 23 days are assigned to groups of four animals, two of each sex if both males and females are used, one group for each test protein level. The weight variation of the animals should not be greater than 6g. The rats should be distributed among the various test groups so that mean weights of the groups fall within 1g of each other at the start of the assay.

b. Diets

To achieve the levels of dietary protein intake described below, the diets are formulated on the basis of Kjeldahl nitrogen content of the air-dry material.

The composition of the protein-free basal diet is as follows:

	g per 100g diet
Maize starch	86
Vegetable oil	10
Salt mix (5)	3
Vitamin mix (25)	1

An alternative diet useful for evaluation of cereal protein quality has also been described (8).

The reference protein diet is formulated by substituting the appropriate amounts of the reference protein for the starch in the protein-free basal diet. Casein is the reference protein (ANRC - high nitrogen casein, available from the Sheffield Chemical Co., Norwich, N.Y. 13815, U.S.A.). Reference protein is fed in each assay at three dietary nitrogen levels: 0.3, 0.8, and 1.3 per cent (equivalent to 2, 5, and 8 per cent protein on an N x 6.25 basis).

When preparing diets, consideration may be given to the need to a) adjust the oil content to take into account the lipid level of the test material, and b) equalize the fiber content of the diets using Alphacel or similar materials.

The test protein diet is prepared in a manner similar to the reference protein diet. Generally the test protein should be fed at nitrogen levels of 0.3, 0.8 and 1.3 per cent; again the test material is incorporated into the diet at the expense of maize starch. If it is not possible to formulate a test diet with a level of 1.3 per cent N because the cereal has too low a protein content, it is recommended that the cereal be tested at levels that replace 33, 66, and 100 per cent of the maize starch. Such an assay would require a maximum of about 900g of test cereal. For many cereals where the N content is higher than the 1.5 to 1.6g/100g range, the amount would be less.

3. Procedure

The rats are placed in individual cages and fed the reference protein diet at a level of 1.3 per

cent N for two days. The rats are then assigned four per group, equalized for weight and sex distribution as above. One group is fed the protein-free basal diet; three groups are fed the reference protein, each at its own prescribed nitrogen level; and three groups are fed the test protein, each at its own prescribed nitrogen level. (Obviously, for each additional test protein, three additional groups of rats would be needed.) All the rats are fed ad libitum for 14 days.

Food consumption and weight gain of the rats are determined at least weekly. Paper or cardboard is placed under cages to permit collection of spilled food, which is freed of feces and weighed daily.

4. Calculation of test values

A table of weight changes, food intake and calculated nitrogen intake is prepared for each animal as in Table III; the data are plotted in Figure 3. Regressions of body weight change on nitrogen eaten are calculated for the reference and test proteins. A satisfactory approximation can usually be obtained by plotting the mean group data for weight change versus nitrogen consumed and drawing the line by inspection (Figure 3). The slope is calculated from the three test protein diets and expressed as a per cent of the slope obtained with the reference protein diet containing casein. Appropriate statistical methods can also be used for calculating the results, testing the linearity of the assay and estimating the errors of the assay results.

The relative protein value is derived as follows:

$$\text{RPV} = \frac{\text{slope of the test material}}{\text{slope of the reference protein}}$$

Relative utilizable protein is a useful index for comparing the nutritive value of materials that differ in protein quality or quantity or both. Relative utilizable protein is calculated simply as RPV x protein content. The latter factor is determined by multiplying the nitrogen content of the cereal by the N conversion factor appropriate to that cereal (20).

The results of some typical experimental runs with different samples of triticale and rice are given in Table IV expressed as RPV and relative utilizable protein.

5. Comments on the method

Aberrant results may be obtained if the levels of protein selected are either too high or too low (8, 34). Unusually high levels of protein intake result in non-linear body weight responses, thus distorting the slope of the curve downwards and underestimating the protein quality. If the response line cuts the y axis below the weight loss of the animals fed the protein-free basal diet, the assay is probably invalid and overestimates the nutritional value of the protein.

There is still uncertainty as to whether the zero protein group should be used in the final analysis of the RPV method for assessing the quality of the cereal protein. Present indications are that inclusion of the zero protein group in calculating the slope may improve the precision of the assay when cereals of low-protein content are evaluated (8, 26). However, others have reported that the dose response assay is improved by omitting groups of rats fed the non-protein diet. This matter requires further study (34).

The recommended method does not provide a measure of the digestibility of the test protein. If this is required, an estimate of apparent or true digestibility may be obtained if fecal nitrogen output is determined according to conventional procedures (16).

C. Relative net protein ratio (relative NPR) method

In circumstances where the amount of material is insufficient for carrying out the RPV procedure, it is suggested that the material may be evaluated for its protein nutritional

Table III.

An example of results of a 14-day RPV assay of triticale

Dietary Regimen	N content of diet (mg/g)	Total feed consumed (g)	Total N intake (g)	Change body wt. (g/14 days)	Mean body wt. change (g/14 days)
Protein-free	0.51	71	0.036	-13.5	
		57	0.029	-18.5	
		46	0.023	-11.5	
		64	0.033	-12.5	-14.0
Casein control (reference protein diet)	3.31	91	0.301	- 3.0	
		68	0.225	-11.0	
		56	0.187	- 6.0	
		71	0.235	- 5.0	- 6.25
	8.15	80	0.652	+ 4.5	
		91	0.742	+ 6.5	
		106	0.864	+16.5	
		115	0.940	+14.5	+10.5
	13.34	152	2.028	+40.5	
		149	1.987	+38.5	
		154	2.051	+44.0	
		156	2.080	+59.0	+45.50
Triticale	3.71	64	0.238	-13.0	
		66	0.245	- 7.0	
		54	0.201	- 7.5	
		50	0.186	- 7.5	- 8.75
	8.54	77	0.658	- 4.0	
		89	0.760	+ 3.0	
		79	0.675	+ 3.5	
		79	0.675	- 0.5	+ 0.75
	13.23	137	1.812	+20.5	
		119	1.574	+17.5	
		88	1.164	+10.0	
		99	1.310	+13.5	+ 15.38

Figure 3.

Relative protein value (RPV) assay of triticale using the slope ratio method

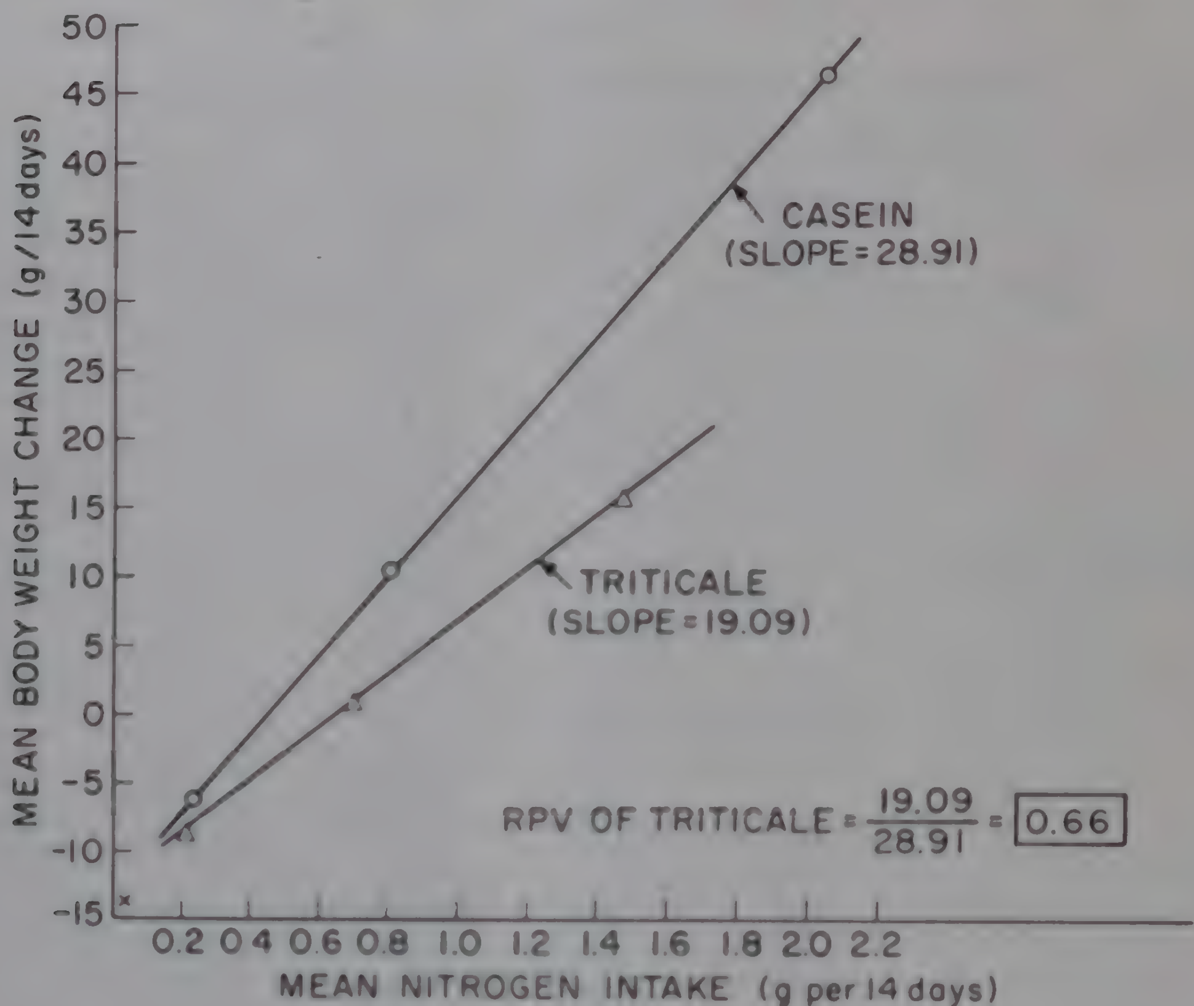


Table IV.

An example of estimates of relative protein value (RPV) and relative utilizable protein in two test samples each of triticale and rice

Protein source	Regression coefficients: Intercept	Regression coefficients: Slope	RPV	Protein content of cereal (N x 5.7)	Relative utilizable protein (RPV x protein content)
Casein	-13.00	28.91			
Triticale (Type A)	-12.74	19.09	0.66	13.02	8.59
Triticale (Type B)	-15.22	22.90	0.79	13.65	10.78
Rice (Type A)	-13.42	24.43	0.84	8.48	7.12
Rice (Type B)	-10.49	18.58	0.64	11.73	7.51

quality by the relative net protein ratio (relative NPR) procedure. This method tends to overestimate the nutritional value of low quality cereals and it does not provide as accurate a quantitative index of utilizable protein as the RPV assay.

The animals, diets and general procedures are the same as for RPV. Three diet groups are included in the relative NPR assay: a protein-free group, a reference protein group (casein) and a test protein group. Recommendations concerning the choice of animals and diets described for RPV apply to this assay. The assay period is 10 days. A single test level of 1.3 per cent N from protein should be used. One group of ten animals is fed the protein-free diet, and depending upon the amount of test material available, a group of five or six animals is given the test diet and another group of five or six is given the reference protein diet. Weight changes and food consumption are derived from data for the 10-day period.

Relative NPR is calculated according to the following formula:

$$\text{Relative NPR} = \frac{\dfrac{\text{WGT \& WLB}}{\text{NT}}}{\dfrac{\text{WGR \& WLB}}{\text{NR}}}$$

Where:

WGT = weight gain of test protein group
WLB = weight loss of basal (protein-free) group
WGR = weight gain of reference protein group
NT = nitrogen consumed by test protein group
NR = nitrogen consumed by reference protein group

This assay would require a maximum of 500g of material, but usually less, depending on protein level of the material under test.

XI. Facilities, personnel and training required for adequate screening programs

The *ad hoc* working group discussed this question briefly but nonetheless deemed it to be of considerable importance in any comprehensive breeding program aimed at improving the protein quality of cereals. Commitments must be considered for the costs of building, equipping, staffing, personnel training and maintaining properly equipped chemical laboratories. A suitable test laboratory "package" would consist of a well-equipped central facility with sufficient equipment and personnel capable of performing all relevant kinds of chemical analyses including many sophisticated types. The central laboratory would have field laboratories associated with it. Research related to the improvement of existing methods and the development of new methods would be among the duties of the central laboratory. One of the top priorities would be to train personnel to operate the more elementary field laboratories where the preliminary screening is carried out as described in this document.

It must be recognized that in some countries, whether developed or developing, useful crop breeding activities are being conducted by competent private individuals or by independent groups such as those at small agricultural universities or experiment stations. Such breeding operations often possess inadequate or minimal resources in the form of the personnel and laboratory facilities needed to screen efficiently for factors reflecting nutritional and other important qualities. The work of such groups should be encouraged, but serious efforts must also be made to draw them into effecting their screening programs in collaboration with the better equipped central laboratories at both the national and international levels.

XII. Issues for the future

The comprehensive discussions that took place at the working group meeting identified a number of important issues that were laid aside in order to complete its principal work within the assigned meeting time. Some of these matters were clearly of such importance that each might merit the attention of other *ad hoc* working group meetings. Others would obviously require additional research. The following topics were identified:

- Feasible targets for protein quantity and quality in cereals:
Components of this question would be an assessment of the tradeoffs between quantity and quality and an examination of the larger issue of protein priorities versus those for yield, productivity, disease and pest resistance, etc.

- Scope, complexity and cost of cereal quality screening programs for developing countries:
Evaluation of these issues must take into account the need to integrate the activities of isolated plant breeding groups into collaborative screening networks. Such an evaluation may also need to consider the establishment of an effective international network, possibly centered in the international agricultural research institutes, to provide crop screening, analytical and testing services to breeders in developing countries.

- Utilization of cereal proteins in relation to nutritive quality:
The apparently low digestibility of rice protein by infants and young children needs study; the questions of the nature and heritability of antinutritional factors remain to be studied. The claim that antibiotics improve utilization of certain plant proteins by chicks and the cause of the phenomenon represent further topics for investigation.

- Inhibition of nutritional response to sorghum and millet proteins by polyphenols:
The chemical identity of polyphenols and related compounds occurring in various sorghums and millets has not been determined. Accordingly, available analytical methods for screening these crops are not reliable. It has been alleged that polyphenols may also influence the nutritional response to triticale; however, the effects of trace amounts of ergot cannot be ruled out as a possible factor in the poor growth performance sometimes observed in test animals fed triticale. More study of this question is urgently needed.

- The urgent need to strengthen collaboration between plant breeders and the international scientific organizations:
The international scientific unions such as the International Union of Nutritional Sciences (IUNS), the International Union of Pure and Applied Chemistry (IUPAC) and the International Union of Food Science and Technology (IUFoST) as well as the International Association for Cereal Chemistry (ICC) should be encouraged to collaborate to take up the problems of the plant breeder with respect to screening methodology.

- Research to standardize biological evaluation procedures for a wide variety of protein materials:
Efforts to standardize biological methods would include tackling the important but unresolved issue of the choice of a standard or reference protein. From a nutritional standpoint a reference protein of higher nutritive value than ANRC casein would be desirable; thus various investigators have begun to use "lactalbumin" as the reference protein source, although specifications as yet have been neither adequately considered nor agreed upon.

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Appendix I

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PAG Secretariat: Dr. Max Milner; Mr. Robert Wersan.

Appendix II

Organizations and institutions suggested for possible international collaboration on screening methods for cereal breeders

A. International agricultural research institutes

1. Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), El Batán, Mexico.
2. Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia.
3. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Hyderabad, India.
4. International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria.
5. International Rice Research Institute (IRRI), Los Baños, Philippines.

B. International agency laboratories

1. Joint FAO/IAEA Division in Food and Agriculture, Agricultural Unit, IAEA Laboratory, Vienna, Austria.

C. International scientific unions

1. International Union of Food Science and Technology (IUFoST).
2. International Union of Nutritional Sciences (IUNS).
3. International Union of Pure and Applied Chemistry (IUPAC).

D. Other technical societies

1. American Association of Cereal Chemists (AACC).
2. Association of Official Analytical Chemists (AOAC).
3. International Association for Cereal Chemistry (ICC).

PROTEIN-CALORIE ADVISORY GROUP

The Protein-Calorie Advisory Group of the United Nations System (PAG) is an interdisciplinary committee of internationally-recognized experts who advise the United Nations and its agencies on technical, economic, educational, social and other related aspects of global malnutrition problems and the broad programs and new areas of activity needed for combating them. Since its inception in 1955, the PAG has emphasized protein-calorie malnutrition as a primary and continuing threat to the health and survival of infants and young children in the developing countries and has played an active role in promoting the development of novel and locally-available protein resources for the developing world. The PAG also reacts to socioeconomic considerations, trends in world food supply and consumption and the need for governmental initiatives and priorities in dealing with these problems.

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The purpose of the PAG Bulletin is to promote the exchange of information on the world malnutrition problem among all those who are motivated to work towards its solution. Published quarterly in English, French, and Spanish editions, it is sent gratis to individuals, institutions, and commercial organizations with an active interest in scientific, technological, economic or social aspects of protein-calorie malnutrition on a worldwide basis.

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NEWS

New Breast-Feeding Organization

The Human Lactation Center, Ltd. was recently organized to coordinate worldwide efforts to distribute information and do research on the effects of breast-feeding on health and population. It plans to work closely with decision makers in government, medicine and industry and to study the nutritional effects on the breast-feeding mother and her infant. In addition it aims to document the psychophysiological benefits of breast-feeding.

The center also intends to create a library to house data on lactation and to publish a new journal, The Lactation Quarterly. Donna Raphael, an anthropologist who has written extensively on the social impact of breast-feeding is the director of the new organization. For further information write: The Human Lactation Center, Ltd., 666 Sturges Highway, Westport, Connecticut 06880, U.S.A.

(More News on Page 21).

COVER

(continued from inside front cover)

The now well-known laboratory was established by the Carlsberg Foundation in 1876; a successor of Kjeldahl was Søren Peter Lauritz Sørenson (1868 - 1939) who is best known for devising the pH scale of acidity and alkalinity. Placed at the threshold of the laboratory is a notice that reads, "No result achieved through the activity of the Carlsberg Laboratory and having either theoretical or practical significance is to be held secret," the statement of a tradition basic to the international character of the sciences.

Thoughts of Johan Kjeldahl and the Carlsberg Chemical Laboratory were certainly far from the minds either of the scientists from several continents who met in Ciudad Obregón, Mexico to draw up PAG Guideline No. 16 or of the Colombian technician in the photo, taken at the Institute for Technological Research in Bogota. Nor would it be reasonable to expect scientists to be actively conscious of their predecessors and traditions as they go about their daily work. Science seldom takes time out to study history; nonetheless it somehow manages to maintain its own best traditions.

The work of Kjeldahl and that of the PAG ad hoc working group--who followed his footsteps more than they realized--as well as of those who may come after them can be placed in perspective. One biographer of Kjeldahl, Ralph E. Oesper, summed it up when he wrote, "Analytical procedures are not found inscribed on tablets of stone but are products of evolution, and their inherent faults, like those of humans, are eradicated largely by the labors of those who work not for their own advancement but for the making of a better world." (United Nations photo.)